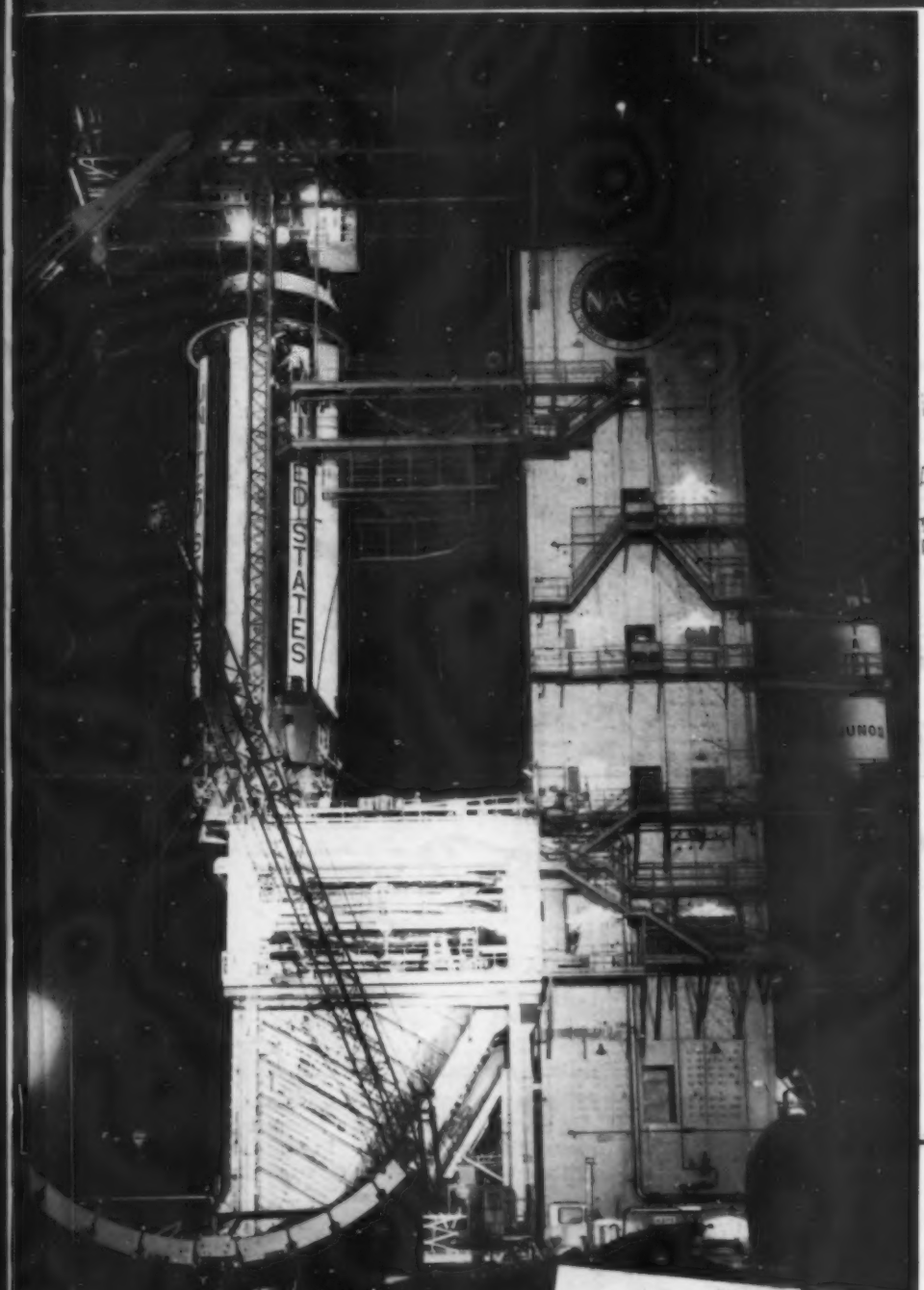
APRIL 10, 1961

missiles and rockets

THE MISSILE/SPACE WEEKLY



V.8 #15

British See U.S. Effort To Corner Market for Missiles

APR 10 1961
TECHNOLOGY DEPARTMENT

- Two Engines Added to Saturn
- Unique Mk73 Directs Tartar
- Glasrock's Wide Potential

Saturn Awaits Static Test

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Military versions of the ALS have been ordered by the Air Force. The Navy has selected it for installation aboard the nuclear-powered aircraft carrier USS Enterprise as well as for its other large carriers.

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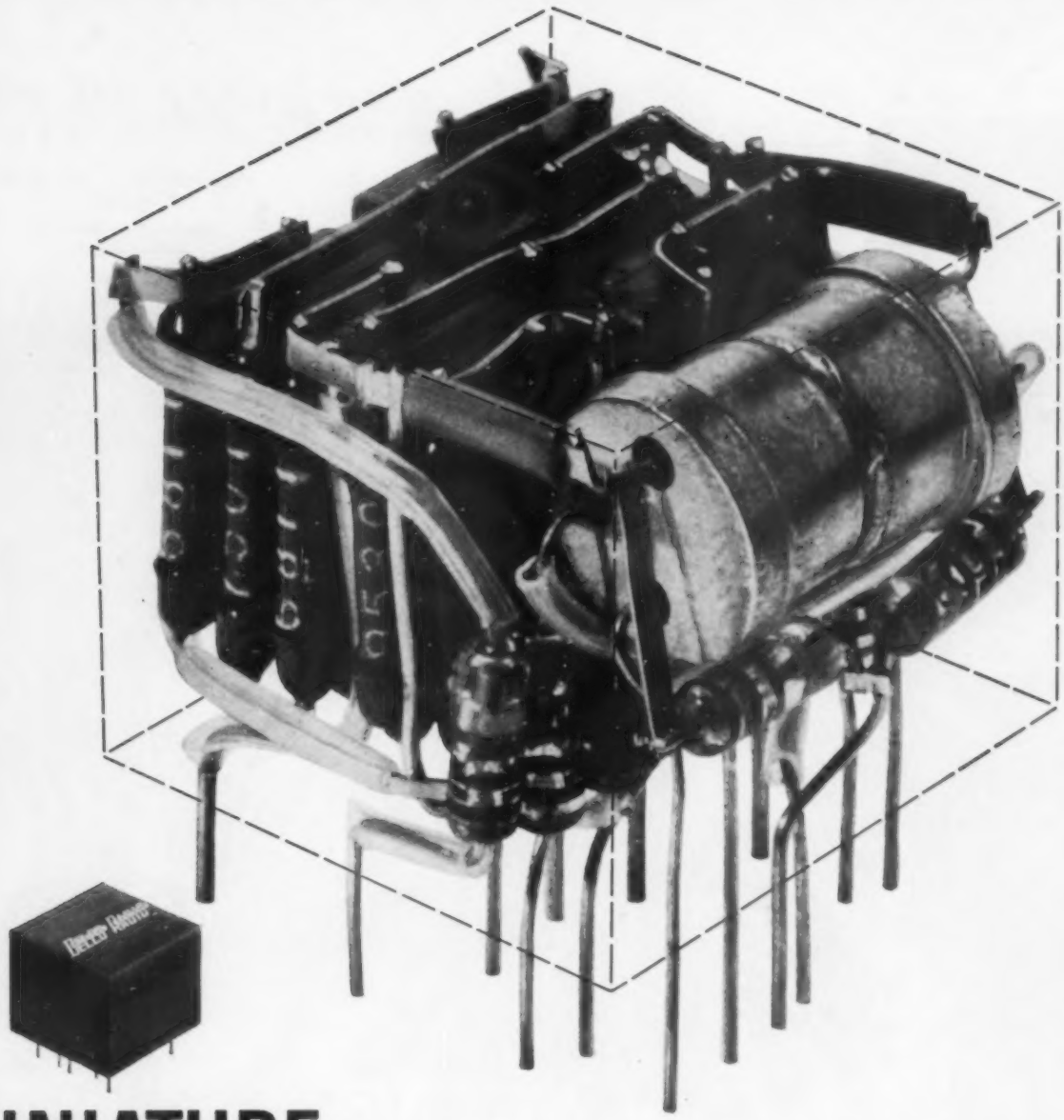

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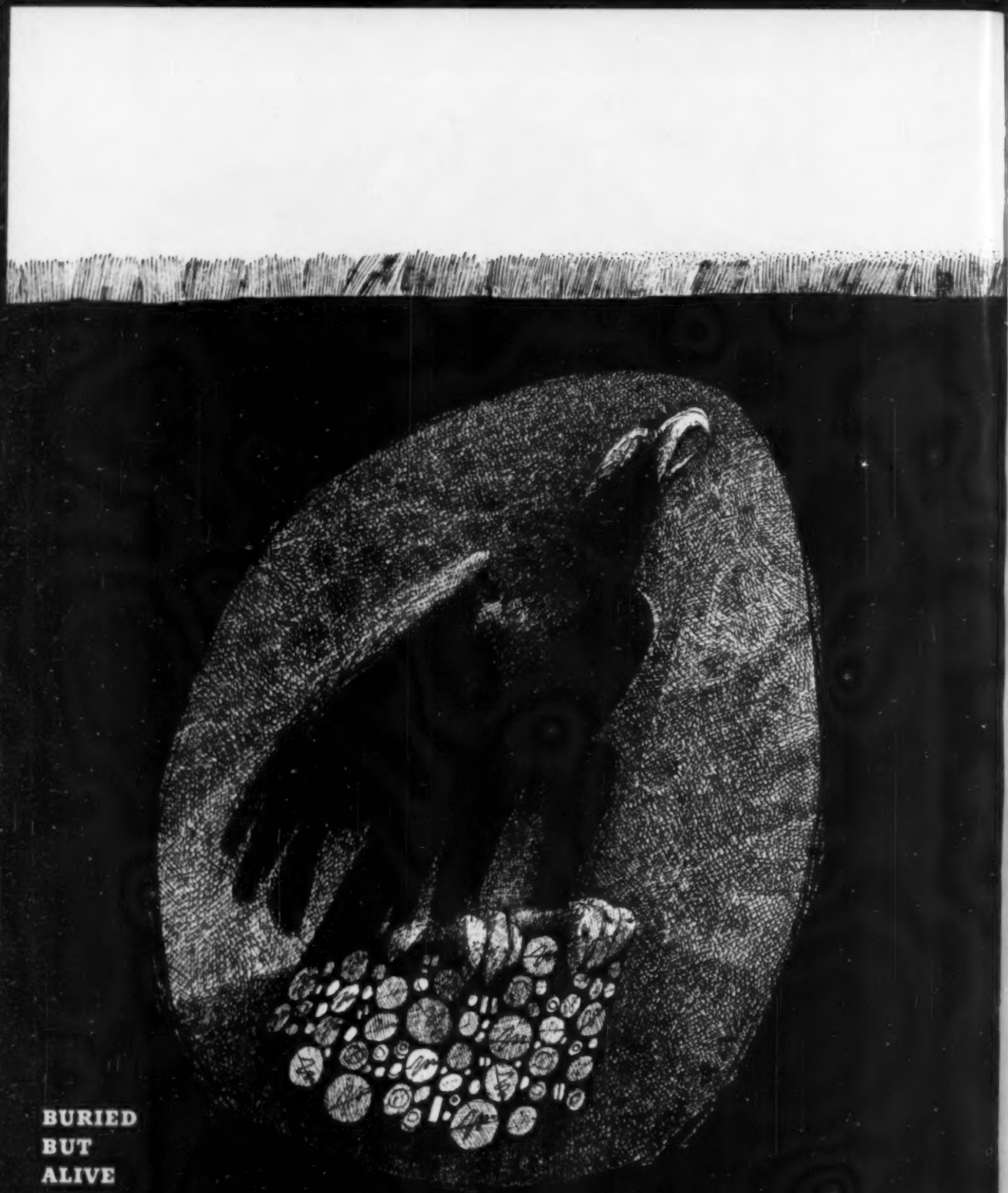

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THE MISSILE / SPACE WEEKLY

missiles and rockets

Volume 8, Number 15 April 10, 1961

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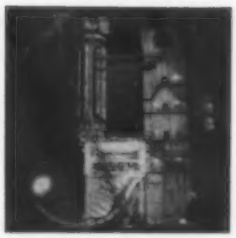
THE COVER



Flight model of Saturn booster waits on stand at NASA's Marshall Center for first static tests. Second-stage configuration has been changed to six engines. See p. 16.

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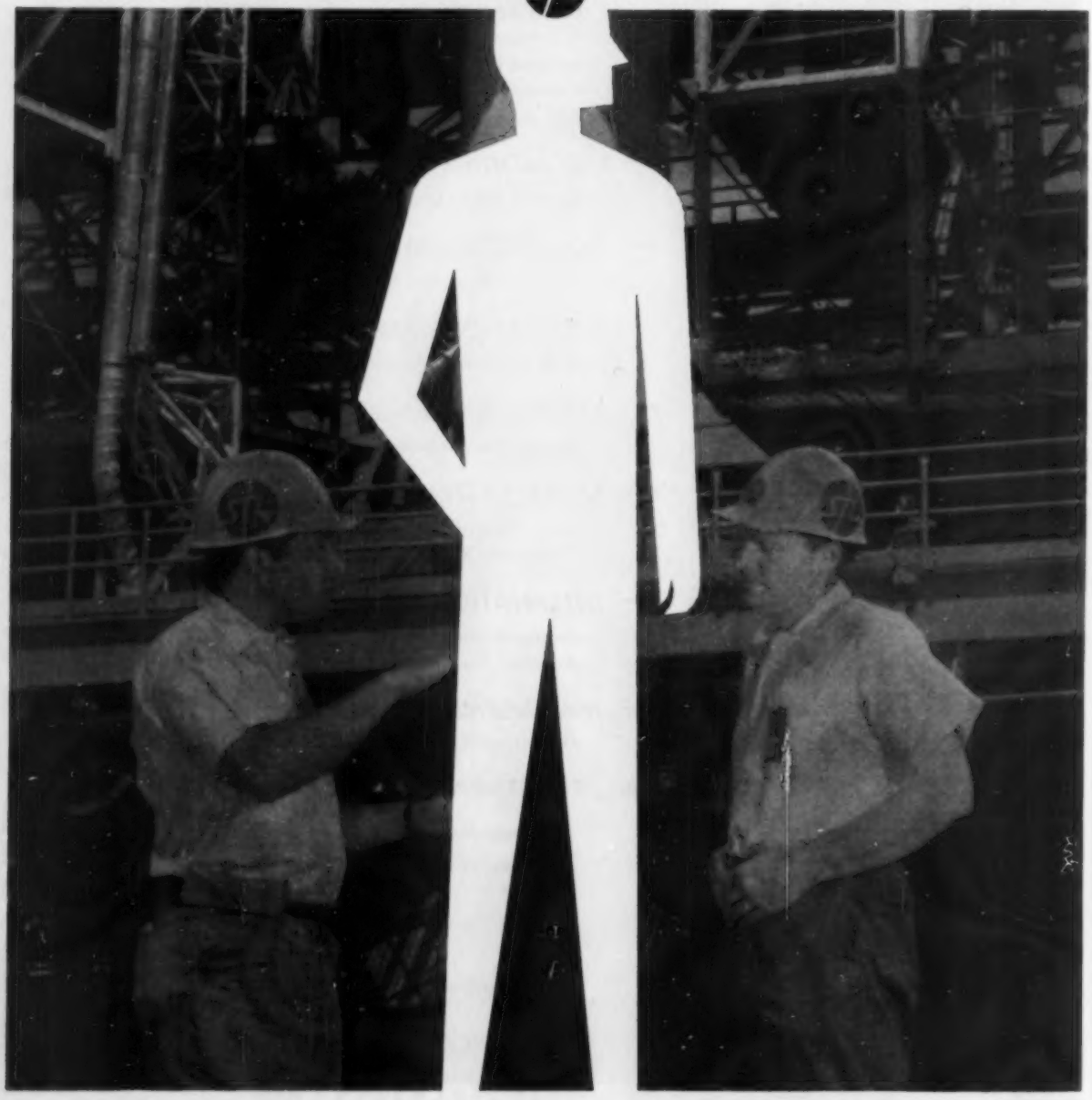


The Countdown

WASHINGTON

Two-Ocean Polaris Fleet Ahead

The Kennedy Administration plan to boost the *Polaris* fleet to 29 submarines gives the Navy the start of a two-ocean *Polaris* force. The next step: Selection of a Pacific *Polaris* Depot. Insiders are betting on Guam. The Navy is expected eventually to deploy two nine-ship *Polaris* squadrons in the Pacific, three in the Atlantic.

Hound Dog Reach Grows

The range of the North American *Hound Dog* is now proven to be in the 600-mile class—a 20% increase over previously announced specifications. The air breathing air-to-surface missiles are being deployed with all B-52 jet bomber squadrons.

STOL's—Not Choppers—for Missilemen

The Air Force, at least for the present, has decided to provide its ICBM squadrons with light STOL aircraft rather than helicopters for hauling missilemen and supplies from central bases to dispersed launch sites. Twenty-nine planes will be bought in FY '61; another 47 in FY '62. Some helicopters still may be bought later. Both STOL aircraft and choppers were tried out at Warren AFB's *Atlas* sites.

Mace B Readied for Overseas

The first squadrons of the new Martin *Mace B* are scheduled to be deployed with U.S. forces overseas this summer. The *Mace B*, unlike *Mace A*, can operate over water. Also unlike *Mace A*, the new models will be deployed in hardened launch sites. Probable deployment site: Okinawa.

First Missile Carrier to Join Fleet

The 60,000-ton Kitty Hawk, first carrier to be armed with missiles, will be commissioned April 29. The Forrestal Class carrier will be armed with Convair *Terriers*. She will have two *Terrier* launchers—port and starboard aft.

Offer Without Takers

NASA is permitting Russian and other Iron Curtain country newsmen to enter Cape Canaveral for the first time to witness the *Mercury Redstone* manned ballistic shot a few weeks from now. So far, however, there have been no takers.

INDUSTRY

Germans Stop Mace Production

West Germany is understood to be reviewing its defense needs and COUNTDOWN hears that one result has been to call off production of *Mace B*. Termination notice went to Martin Co. last month. The order for Germany had been tacked onto the end of the Tactical Air Command *Mace* order, so there will be no immediate effect from termination, except on some subcontractors. Award of the contract for the West German *Maces* was made last November, but never announced in order to avoid criticism that the U.S. was arming a former enemy.

R&D Intelligence

Trend now in glass-plastic rocket motor cases is toward single nozzle design, with nozzles wrapped integrally with the case. This requires a secondary system for thrust vector control, which is justified by design and weight advantages. . . . GE-Philadelphia has a 12-month NASA study contract on the feasibility of a magneto-hydrodynamic propulsion system powered by SNAP-8. . . . Aluminum-coated fiberglass containing U3P8 is being roll-cladded by Clevite Corp. as fuel elements for nuclear reactors.

Arc-jet Studies Extended

Six months and $50,000 are being added by NASA to two competing contracts for developing laboratory models of arc-jet engines. Avco-Wilmington and GE-Cincinnati have been working on the engines under $250,000 contracts for the past year.

Nuclear Rocket Pushed

With the development of *Saturn* in sight, the push is on to start developing a nuclear rocket upper stage. Martin Co.'s William Bergen contends RIFT (reactor-in-flight-test) study for NASA shows a 1966-67 target date to be "realistic" and that with *Saturn* a nuclear system could put 35 tons in orbit. . . . Two Douglas Aircraft engineers are advancing a plan for a nuclear electric rocket which would be propelled by supercharging a solid core reactor, using highly efficient thermionic units to speed gas flow with electrical and magnetic fields. . . . Reasoning behind NASA-Huntsville's study plan for launching *Saturn* from a Texas Tower-type pad in the sea off Cape Canaveral is safety when a nuclear stage is flown.

INTERNATIONAL

New British Secret Missile under R&D

COUNTDOWN hears that one of the most closely guarded new missile projects in Britain is work on an advanced antisubmarine missile. This may explain much of the recent alarm over the British spy trial involving the Royal Navy underwater test station.

Space Club Troubles

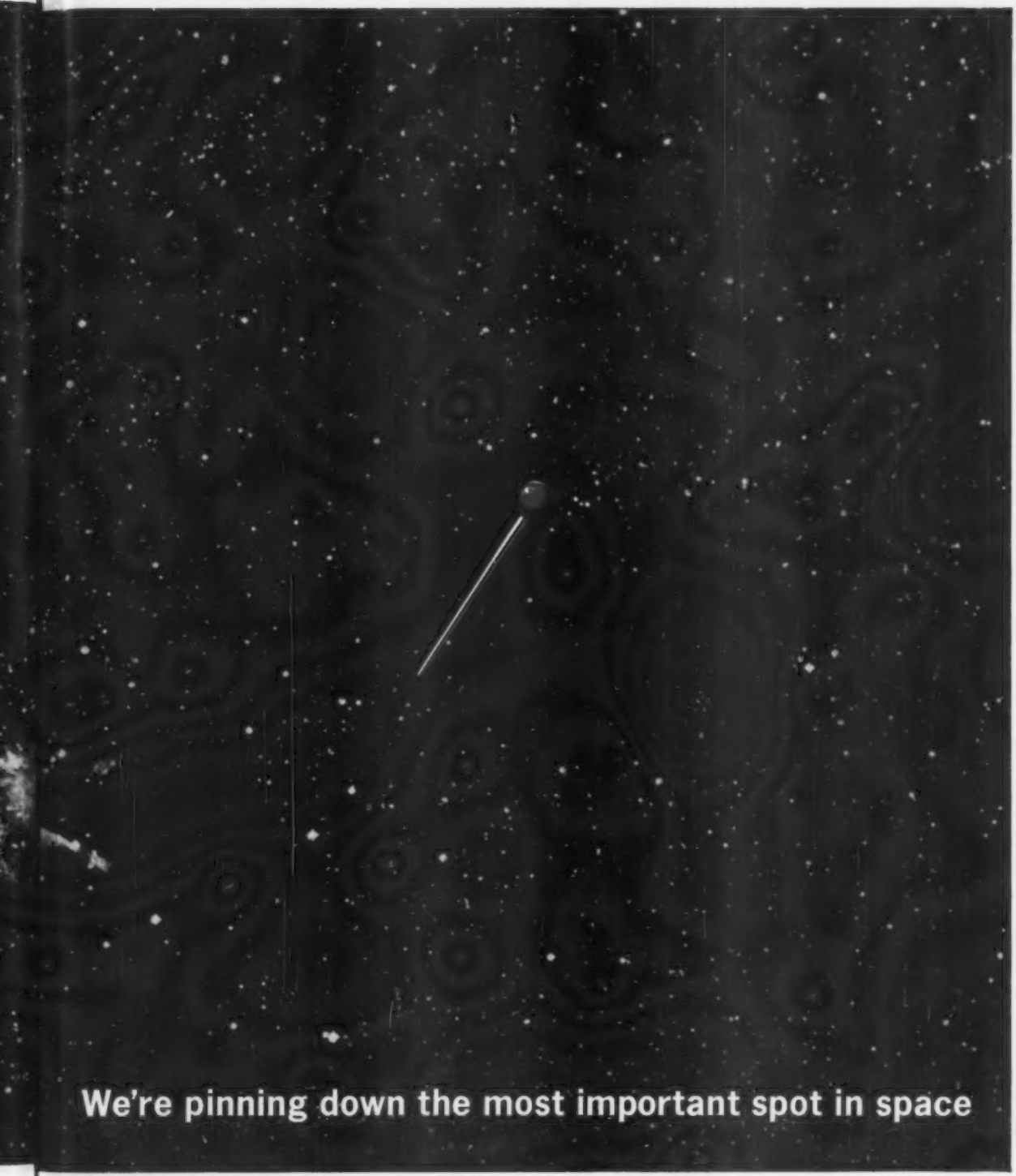
Italy is declining to join in a cooperative European satellite launching program because it doesn't want to make any commitment "on specific vehicles and/or hardware" already in existence. However, the country will stay in the European Space Research Organization.

Overseas Pipeline

Electronic divisions of Armstrong Whitworth Aircraft and Brush Electrical Engineering, both members of the Hawker Siddeley Group, are consolidating. . . . The British are said to be investigating radio signals being beamed from the Scottish mainland to Russian trawlers lying in an area where *Polaris* subs must pass after leaving Holy Loch. . . . and there's a report the Soviets at one of their R&D centers already are building a prototype of the caterpillar moon-crawler depicted in their space literature.

It's the point where men will first rendezvous in space. It could be any point. The trick is getting two men there at the same moment when they're traveling at orbital speeds or greater.

Northrop is already working on many of the technical problems that are still to be solved before the first men can meet in space . . . rendezvous trajectory analysis, for instance, and spacecraft maneuverability, navigation and propulsion. Active studies are under way in various phases of space medicine and human engineering for crew survival in space, and on in-space rescue, repair and refueling techniques. Important new ground has already been broken in the area of re-entry, recovery and landing systems for space vehicles. In short, Northrop is active in almost every phase



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The Missile/Space Week

Labor Trouble at Lowry

Walkout of 400 Martin workers at the *Titan* Site 1-A near Lowry AFB, Denver, will affect the operational status of that site on a one-to-one basis, the Air Force has charged. This means that every day lost during the walkout will push back the operational date—set for late summer—by one day.

The work stoppage occurred over a jurisdictional dispute between the United Auto Workers Union and the Operating Engineers Union over powerhouse operations. The Martin Co. has denounced the walkout as "unfair" and has turned over the matter to the National Labor Relations Board. The stoppage has not been termed a "strike" since there is no picket line operating as yet.

The action apparently was triggered by a few protesting operating engineers. Some 25,000 man days have already been lost through strikes and walkouts since the beginning of construction at the Lowry *Titan* emplacements, an Air Force official estimated.

Holes for Minutemen

Test borings will begin shortly at Air Force bases in three states for the three *Minuteman* squadrons designated in the Kennedy budget.

Surveys are being conducted for possible hardened bases at Tinker AFB, Oklahoma City, Reese AFB, Lubbock, Tex., and Whiteman AFB, Knob Noster, Mo.

A $1-million contract for five *Minuteman* emplacement systems was let by Boeing last week to The Bendix Corp.

The system includes a hydraulic power supply, two erector-activators, a hoist, control panel and interconnecting equipment for lowering the missiles into underground launchers.

Delivery of the first unit is scheduled for this fall.

Shot of the Week

The fizzle of a *Titan* missile Mar. 31 slightly dimmed the Air Force's elation over a perfect shot just two days before. The Martin-built bird was scheduled for an extended range trip of about 10,000 miles, but plopped into the ocean soon after launch, apparently due to a premature first-stage cutoff.

Army Missile Contracts

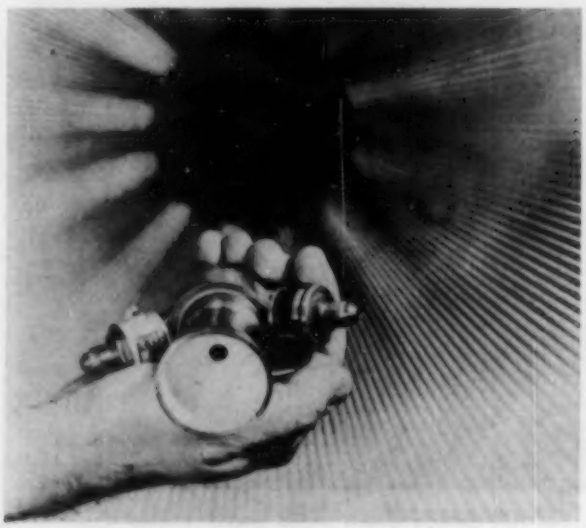
The Army awarded some $70 million in missile contracts last week.

Raytheon Co. received $57 million in contracts on the *Hawk* missile system and ground support equipment, including $20 million for missiles.

Sperry Rand's Utah division got a $6.8-million contract for continued production of the *Sergeant* missile, and Convair Division of General Dynamics copped a $5.9-million follow-on contract for *Mauler* antitank missile production.

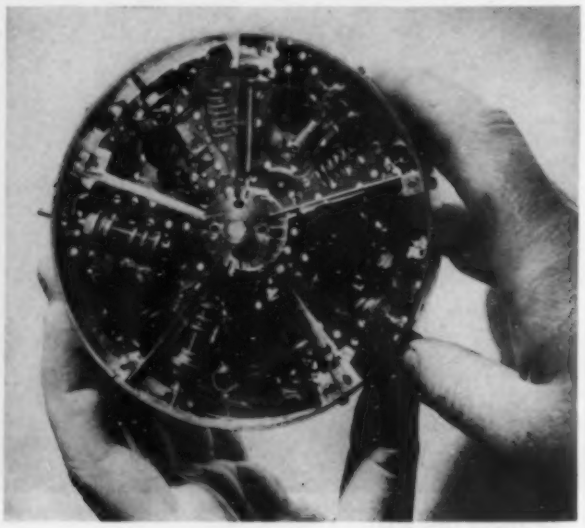
Nerva Prime Contest

Seven companies filed proposals with the NASA-AEC Nuclear Propulsion office last week for the prime contract on the Nerva nuclear rocket



Compact Power Package

ONE-POUND ROCKET ENGINE developed by Reaction Motors, Thiokol Chemical Corp., delivers controllable pulses as frequent as 22.5 per second for attitude control and station keeping of satellites. Available in thrust ratings from ½ to 10 lbs. the Starmite rocket occupies 5 cu. in. It operates uncooled for extended periods on various self-igniting liquid bipropellants. Continuous firings as long as 10 min. have been recorded.



'Mother-Daughter' Talk

TINY RECEIVER for 72-megacycle signals proposed for ionospheric studies. Under a $25,300 NASA contract, Pennsylvania State University is studying plan to launch twin payloads with Javelin rockets to altitudes up to 1500 miles. "Mother" and "daughter" would then separate, and electron density would be measured by comparing phase differences between signals on 6, 12 and 72 mc transmitted from "daughter" to "mother."

engine, the flight engine for Project *Rover*.

The contract—expected eventually to lead to $1 billion in business over the next decade—is expected to be awarded in six weeks to two months. Bidders are Rocketdyne Division, North American Aviation; Aerojet-General Corp.; Pratt & Whitney Division of United Aircraft; Reaction Motors Division, Thiokol Chemical; Westinghouse; General Electric; and American Metal Products Co., Ann Arbor, Mich.

The initial contract will call for only the first phase of the program—providing backup and assistance for AEC's Los Alamos Scientific Laboratory in preparations for the *Kiwi-B* test later this year. The size of the job to be done in the first phase will depend on how much money Congress appropriates for *Rover* in the coming weeks.

And Bids on Rebound

NASA's Goddard Space Flight Center received bids from eight companies last week on spacecraft design and development of orbital placement technique for the Project *Rebound* communication satellite system.

Rebound calls for multiple launchings of 135-ft.-diameter rigidized *Echo*-type spheres. First launching—in mid-1963—will be three aboard an *Atlas-Agena B*. Later launchings call for six satellites on a *Centaur*.

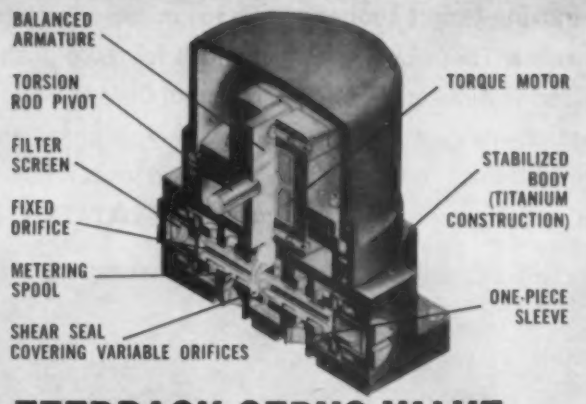
Bidders were AMF, Lockheed, Convair, Goodyear Aircraft, RCA, Republic Aircraft, Avco and Douglas. Actual fabrication will take place under a later-phase contract.

U.N. Meeting Not in Cards

The United Nations Conference on Peaceful Uses of Outer Space seems to be out for 1961.

No negotiations have been held between the United States and Russia on the subject since the Kennedy Administration took office in January. Since eight months of lead time is considered necessary for planning, U.S. diplomats now have almost given up any hope of holding it this year, as originally proposed.

There is some speculation that the conference might be included in a package agreement with Russia on a group of related subjects.



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Hysteresis	3% maximum total rated current	3% maximum total rated current
Supply pressure	300 to 3000 psi	300 to 4000 psi
Proof pressure	4500 psi pressure port 3000 psi return port	6000 psi pressure port 3000 psi return port
Pressure gain	First stage—500 psi per ma minimum with 3000 psi supply	First stage—500 psi per ma minimum with 3000 psi supply
Load pressure gain	8500 psi per ma minimum with 3000 psi supply	10,000 psi per ma minimum with 3000 psi supply
Temperature	−65°F to +275°F	−65°F to +275°F
Maximum Null Shift Temperature Change per 100°F	(% of rated current) 1%	1%
Supply Pressure Variation ±	2%	2%
Quiescent Current Change 20%	1%	1%
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Rated Current	± 10 ma	± 8 ma
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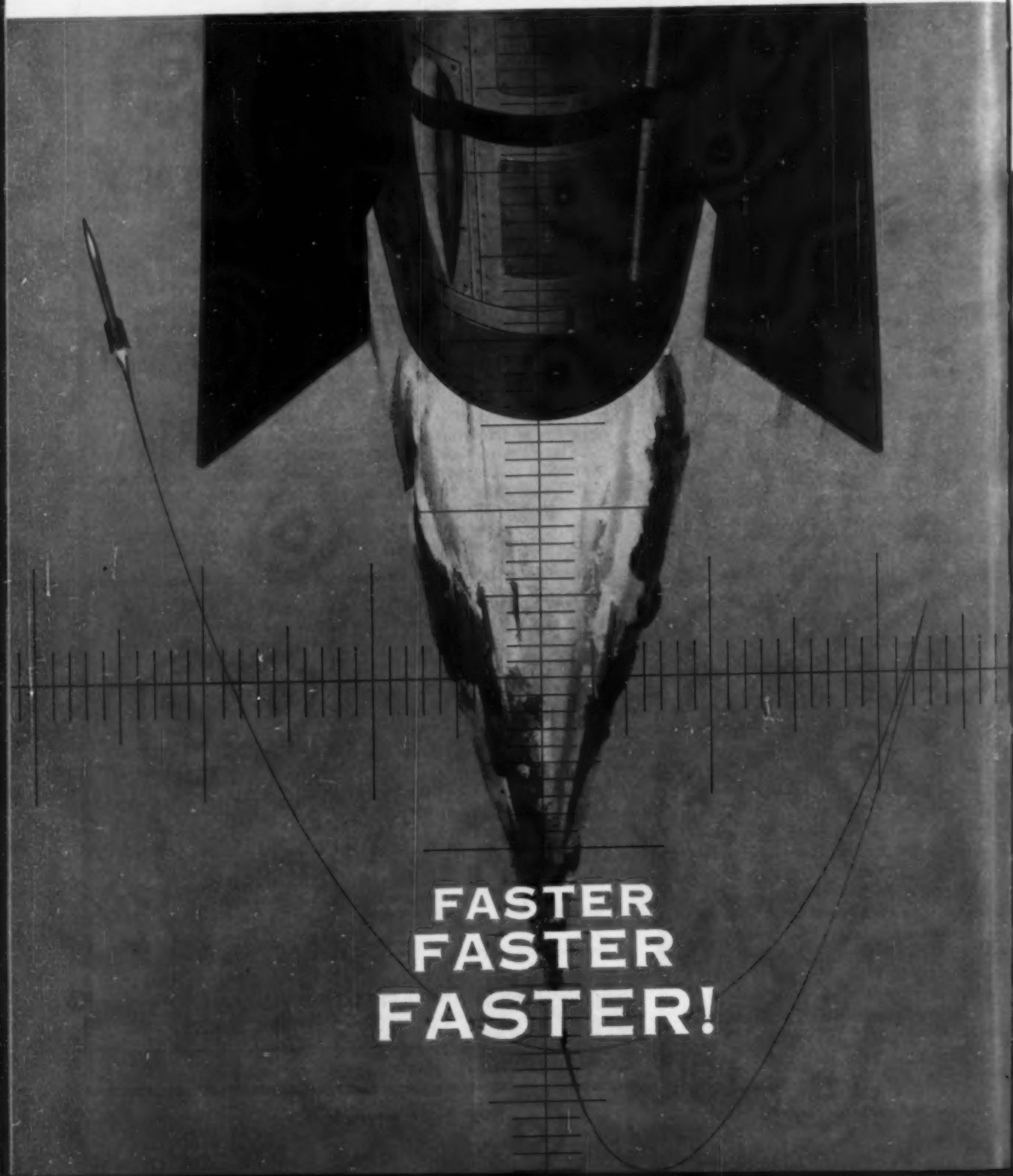
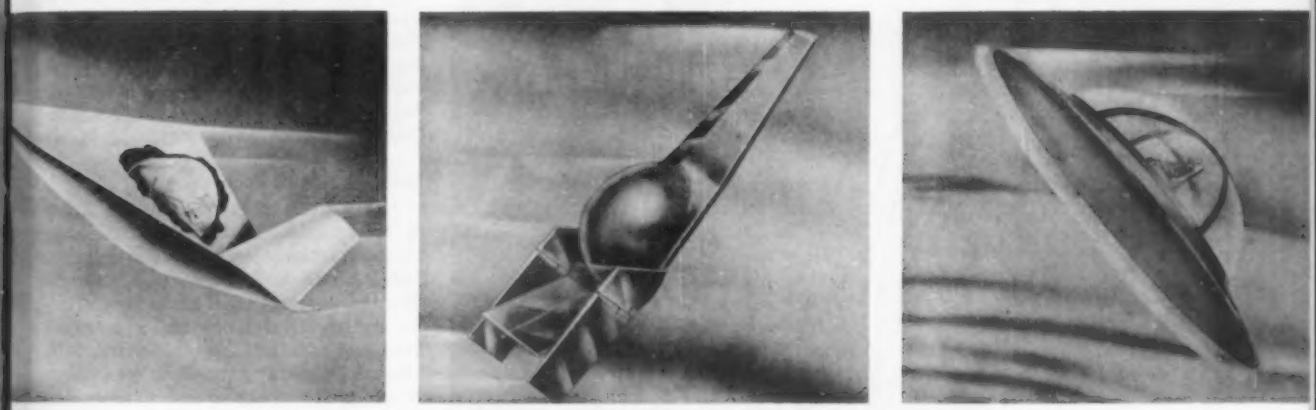


British Missile Men Warn Against U.S. Drive Toward Monopoly

Blue Water vs. Sergeant is immediate argument; Franco-British study stirs interest in West Germany and Italy



IDEAS FOR MANNED spacecraft being advanced by British Missile Men.

by James Baar

LONDON—British industrialists are charging privately that elements of the U.S. Missile/Space Industry are trying to monopolize the missile and space market in the West.

The British contend that if the attempt succeeds it will result in a partial undermining of the European economy and a tremendous gain for the Soviet Union in the East-West space race and the Cold War.

The charge is a major underlying factor in current European talks aimed at establishing a cooperative European space program along the lines of proposals made in the recent Franco-English study produced by SEREB and Hawker-Siddeley Aviation Ltd.

The charge also was a major underlying factor in the recent secret talks in Washington between Defense Secretary Robert McNamara and British Defense Minister Harold Watkinson. It was expected to be an issue at last week's meeting between President Kennedy and British Prime Minister Harold Macmillan.

The message that key industry officials in Britain hope both Watkinson and Macmillan were able to get across is that the United States has far more to gain by sharing the missile/space pie.

The British contend that one of the more outstanding of these gains would be the acquisition—at relatively bargain prices—of a new and large reservoir of first-rank brain power for work on many advanced space study programs.

• **Test case?**—The English Electric missile *Blue Water* is the immediate cause of contention between U.S. and British missile manufacturers.

The *Blue Water* and the American Sperry *Sergeant* are under consideration for filling NATO's requirement for a short-range tactical missile. Both are powered by solid propellant. Both are highly mobile. Both have a range of about 75 or more miles. Both are in production.

The competition from any standpoint is very, very warm.

The British have charged that the United States has brought considerable pressure on the NATO nations to adopt the *Sergeant*. The suspicion has been raised that the Kennedy Administration sees the sale of *Sergeant* to NATO as a boon in helping to halt the flow of gold from the United States.

Whether this is true or not, many British industrialists see *Blue Water* as a test case. As one company official not associated with English Electric put it:

"It's a test of good faith. *Blue Water* is a very fine missile. We think it is better than *Sergeant*. NATO should buy it. If the United States takes away the entire market, we won't be able to continue and the West will be the poorer."

Another official recalled the British decision to buy Douglas *Skybolts* from the United States.

"Here was a situation where we didn't have the missile; therefore we are buying it from Douglas," he said. "This was the cheaper way. There was no sense in us both developing the same thing. We could have, but it made economic sense at least in the short run not to do so."

• **Two-way street**—However, he added pointedly that both the United States and Europe would benefit if such decisions worked both ways.

"After all," he said, "if when the first Model T was manufactured in the United States we had bought it and every model after it and had not made motorcars ourselves we would have had no motorcar industry. Then where

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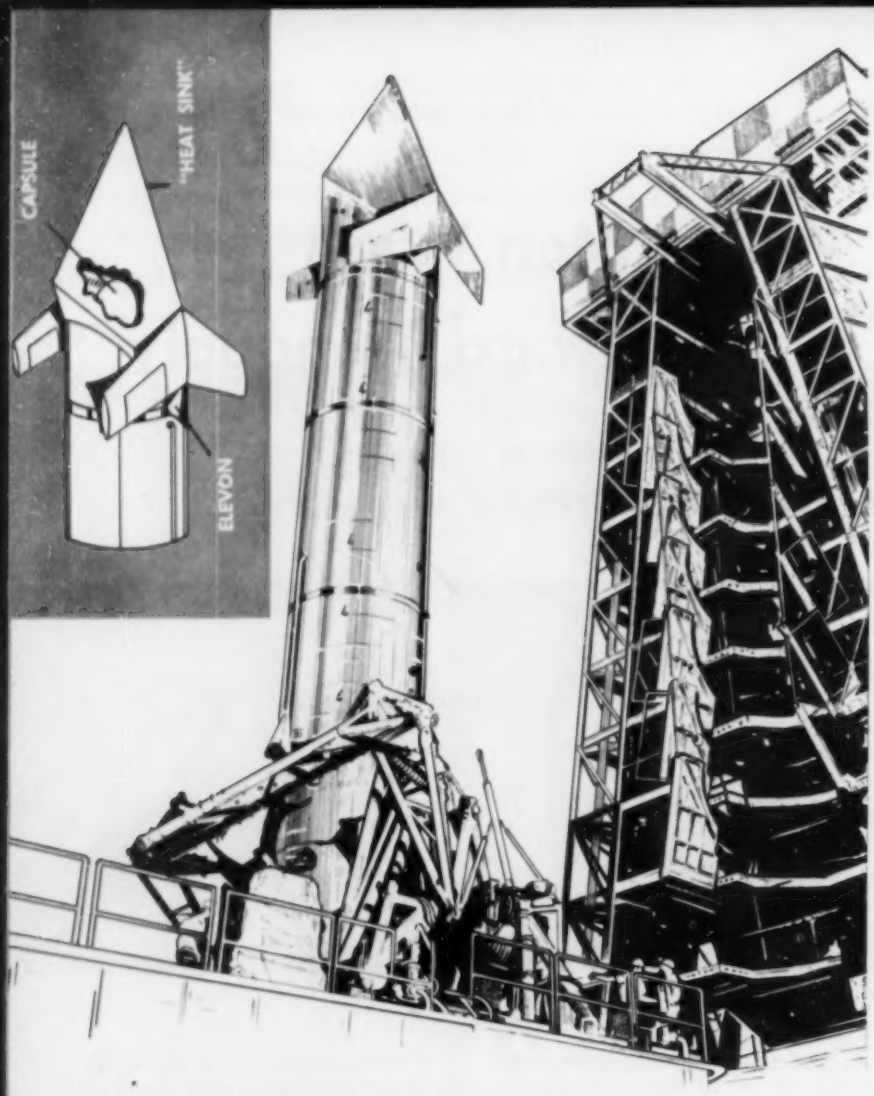


BRITISH DYNA-SOAR perched on a de Havilland Blue Streak as envisioned in an 18-month-old technical study by Sir W. G. Armstrong Whitworth Aircraft Ltd. It is one of several advanced studies which the British have completed demonstrating the capabilities which they contend are being left unused.

would we have been in World War II?"

The SEREB-Hawker Siddeley study sounded these various themes in unmistakably clear tones.

"The progress our nations will make in the field of advanced (space) techniques will be a governing factor as concerns their future place in relation to the great powers of today," the study said.

"Let us suppose for a moment that the European nations show not the slightest interest in aerospace studies. The result would be that the technical and commercial advantages which stem from space ventures would have to be acquired from abroad. Translated into commercial terms, this would mean the purchase of licenses for products and manufacturing methods which would have wide applications . . ."

At another point, the study said "Western Europe represents a vast intellectual potential and it would be unfair to our scientists and designers to pretend that the human resources were not available."

• **Cost and profits**—It said beginning a European space program "boils down essentially to an organizational and financial problem." And, it noted that from a financial standpoint European space programs had a large advantage over American programs.

The study said that because of differing price levels a European space project could be financed for 60% of what it would cost in the United States. Moreover, it said that the "vast expenditure" in the United States on missile and space projects can be attributed in part to circumstances which are "clearly political." Among these circumstances were listed: "Reasons of prestige . . . interservice rivalry . . . and the tendency to do things in a big way."

The study also pointed out that the longing to realize immediate profit was not found exclusively on the western shores of the Atlantic.

"The European countries may be tempted to bring their initial effort to bear on exploiting results already attained," it said. "The extent of available funds to be devoted to this work must remain within acceptable limits so that the research and development of new techniques is not jeopardized."

• **"We can help"**—One little-noted passage in the study was possibly the most significant. It referred to the possibility of a future space war between the East and West.

"For some time," the study said, "a growing number of far-sighted people have warned of the probability of an approaching space war. Space will be the enemy's observation post, the base for attacks against terrestrial targets. And, above all, the place where an attempt will be made to destroy or neutralize the enemy's resources."

One British missile industry official made the point even stronger.

"We are in a period of nuclear deadlock," he said. "Both sides are building up their missile arsenals. Possibly the balance will tilt one way or another. But the Russians see a better way. They are going to reach into space to break the deadlock. If they are successful, there would not necessarily be a war. There will be nothing cataclysmic, just an accommodation."

He smiled and shrugged.

"We can help America in this race," he said. "We might even show America a trick or two. Our people could work on these advance problems which they have no reason to work on now. Then, when we have reached a higher stage in our own space progress, we could borrow back the answers.

"Now our talent is being wasted. While Europe and the United States compete to sell a missile or two, Russia goes ahead. But Western Europe doesn't understand; it doesn't see the danger. Neither apparently does America."

• **Stirrings**—However, there are signs of some awakening to the danger.

Companies in both West Germany and Italy have expressed considerable interest in the Franco-British study. Both the British and French governments have shown increased signs of proceeding with a space program alone if necessary.

But it is clear that only fuller cooperation from the United States can give a European program the impetus that it will need for rapid progress. Such cooperation certainly will not be forthcoming from Washington until the Kennedy Administration reaches a decision on what it will do in space itself. ⌗

Preliminary policies . . .

Defense Plans Could Easily Change

SHARP CHANGES in the nation's defense policies and programs can still be expected from the Kennedy Administration anytime within the next nine months.

Defense Secretary Robert McNamara conceded this last week that the new Kennedy defense budget and the policies on which it is based are only preliminary.

McNamara said his "complete reappraisal of our basic national security policies, plans and programs" may not be completed before Congress adjourns.

This would mean the full impact of the reappraisal would not be felt until the defense budget for FY '63 is put together. However, McNamara said if further changes are "found to be essential" before then, they will be put before Congress promptly.

Meantime, the Defense Secretary explained the new obligational authority and other details of the defense budget in public and secret testimony before the Senate Armed Services Committee. He said:

— The additional $96 million for *Minuteman* included $36 million to double production capacity; $24 million to extend the missile's 5000-nautical-mile range and improve its "reliability, accuracy and penetration capabilities;" $10 million to switch from three mobile to three fixed squadrons; and $26 million for additional training missiles. The switch from mobile to fixed squadrons brought the total number of planned fixed *Minuteman* squadrons to 12—a total of 600 missiles.

Polaris Sub Commissionings

	(Calendar Years)							
	1960	1961	1962	1963	1964	1965	1966	1967
Eisenhower Schedule	No. 2-3	No. 4-6	No. 7-9	No. 10-13	No. 14-18	No. 19-23	No. 24-28	No. 29
Kennedy Schedule	No. 2-3	No. 4-6	No. 7-9	No. 10-18	No. 19-29	—	—	—

—The additional $1.39 billion for *Polaris* included $1.22 billion for 10 submarines, a tender and long-lead time items; $60 million to accelerate R&D for the A-3 *Super Polaris;* $15 million for additional *Polaris* personnel; and $42 million for more training missiles. The speed-up meant that a fleet of 29 *Polaris* subs could be deployed about two years earlier than under the old Eisenhower schedule and added 10 more submarines than Eisenhower had requested.

—An additional $302 million for space research and "other projects" included $30 million for *Dyna-Soar;* $60 million for the *Midas* early warning satellite; $21 million for *Defender* antimissile system studies; $15 million for the *Advent* communications satellite; $30 million for *Discoverer;* and $14 million for the *Saint* satellite inspection system. "Other" received $132.4 million. Possibly much of it went to the *Samos* reconnaissance satellite. The $30 million for *Dyna-Soar* was only a third of what the Air Force sought.

—The refusal to provide any money for interim production of the *Nike-Zeus* antimissile missile was based on "considerable uncertainty as to its technical feasibility." McNamara said "there are widespread doubts as to whether the *Nike-Zeus* system should ever be deployed." However, he said the Administration was requesting $276 million to continue the *Zeus* R&D program leading to system tests next year.

McNamara said the Kennedy Administration was basing its first defense budget on a policy aimed at reducing "our dependence on deterrent forces which are highly vulnerable to ballistic missile attack or which rely for their survival on a hair-trigger response to the first indications of such an attack."

"Of the four strategic missiles now in production or under development, the *Polaris* has the highest degree of survivability under a ballistic missile attack," he said. "The *Minuteman,* since it can be widely dispersed in well-hardened underground sites, should also have a high degree of survivability." ⌗

Army to Control Reconnaissance Payloads . . .

KEY AGENCY in a new DOD plan for collecting and plotting reconnaissance data will be the Army's GIMRADA (Geodetic Intelligence Mapping Research and Development Agency) at Fort Belvoir, Va. It will write payload specifications.

Defense Secretary McNamara, seeking to head off more "overlap and duplication" among the services, last week assigned the Air Force responsibility for collecting reconnaissance data in space and gave the Army the mission of reducing it and processing it.

While the Air Force will perform the actual development of satellite instrumentation and processing equipment, GIMRADA writes the specs—presumably even for the payloads the Air Force is interested in. This latter provision is understood to be the major reason why the Air Force objected to McNamara's directive reassigning responsibilities. The Air Force also objected to losing control of data reduction.

However, Deputy Defense Secretary Gilpatric maintains there will be no change in the intelligence system for pinpointing Soviet targets. This will remain the responsibility of the Joint Strategic Targeting Center at Strategic Air Command headquarters, Omaha, which will work from original data and photographs provided by *Samos* reconnaissance satellites to locate Russian missile and air bases. But the targets will be plotted on Army maps.

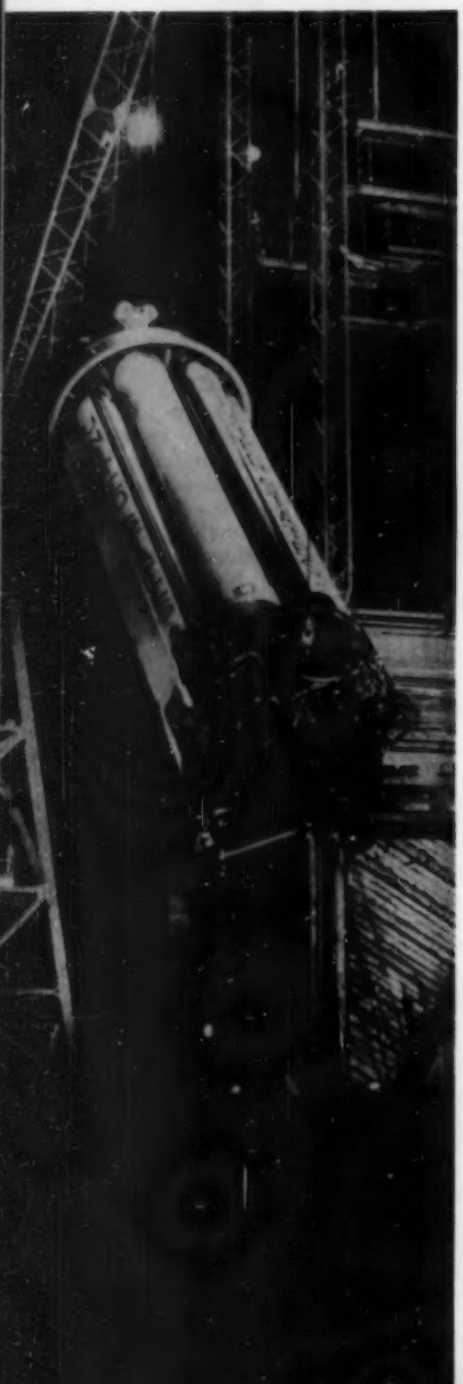
The Army Map Service will set up and manage a single geodetic and mapping program for all three services. This will include a world-wide master geodetic control system and geodetic library.

Gilpatric indicated that the operations of the Air Force aeronautical chart service at St. Louis would be curtailed where they overlap new Army functions.

Gilpatric said the Joint Chiefs of Staff were asked to arrive at a division of responsibility to "eliminate confusion." Their draft of the directive—with the Air Force disagreeing—was used as the basis for McNamara's directive. This was far different from the handling of the directive in which McNamara gave the Air Force the primary military mission in space (M/R, March 13, p. 16). Then, McNamara by-passed the JCS, touching off a furor among the services. ⌗

FLIGHT-MODEL Saturn booster is lifted onto stand for static tests to begin soon at Marshall Center.

Engines Added to Saturn C-1



NASA ups second-stage configuration from four to six to avoid possibility of slip in schedule; increase to 90,000 lbs. of thrust will enhance maneuverability and control

by Jay Holmes

THE SATURN C-1 second stage will have six engines, not four, with total thrust of 90,000 lbs.

The National Aeronautics and Space Administration decided last week to change the configuration of the Douglas *S-IV* stage, which would have had 70,000 lbs. thrust with four engines.

The Pratt & Whitney *LR-115 Centaur* engine, with 15,000 lbs. thrust, will be used in the new cluster. NASA halted development of the P&W *LR-119*, a follow-on liquid hydrogen-burning engine of 17,500 lbs. thrust.

The change will require some reworking of the *S-IV* vehicle hardware. Douglas Aircraft has been working since last summer under a $65-million contract to develop and deliver 10 of the vehicles, which measure 50 ft. long and 18 ft. in diameter and carry 100,000 lbs. of propellant for a total loaded weight of 110,000 lbs.

• **Delays avoided**—NASA made the *S-IV* change primarily because of concern for meeting schedule. The first *Saturn*—No. 4—with live second stage is to be flown in early 1963. The *LR-115* engine development has run into trouble in the last few months; the first *Centaur* flight has slipped from early summer to the fourth quarter of this year.

Centaur uses a pair of *LR-115* engines atop a modified *Atlas* booster. NASA propulsion specialists feared the delay in the *LR-115* would cause comparable delay in the follow-on *LR-119*. Furthermore, they felt that Pratt & Whitney should not be burdened with developing a second engine before the first is out of the woods, and that the relatively small thrust increase attainable with the advanced engine would not be worth the risk of lost time.

High thrust is desirable on the *S-IV* stage so as to give high maneuverability and control from the gimbaling of individual engines. With 70,000 lbs. total thrust, NASA vehicle specialists felt there was only marginal capacity to control the stage. The six-engine cluster will improve control capacity.

NASA vehicle specialists see two other advantages in the change. First, the six-engine cluster consumes the highly volatile cryogenic propellants more rapidly, reducing total burning time from 600 to 433 sec. Second, use of six engines gives more capability of "engine out" operation.

The six engines will be in a circle, all swiveling in response to the control system. Just as in the eight-engine cluster of the big booster, if an engine fails those remaining will be able to use its propellant, and the control system will adjust the thrust vector appropriately.

More money is being pumped into the *LR-115* program, to prevent further loss of time. In the Fiscal Year 1961 supplemental recently approved by Congress, *Centaur* gets $16.2 million of the total $49 million granted to NASA. At the time of the request, the money was sought for vehicle development and system support. However, inasmuch as engine development has become a critical area, some of that money will go for engine work.

In addition, President Kennedy has asked Congress to increase the *Centaur* 1962 funding by $25.6 million—from $30.8 million to $56.4 million. Much of that additional money will go toward preventing further loss of time on the *LR-115*.

The schedule calling for a two-stage *Saturn* launching early in 1963 represents some slippage from the timetable announced last September at the Marshall Space Flight Center industry conference. At that time, three launchings—

(Continued on page 18)

U.S. Presses Effort on Centaur

THE UNITED STATES is pumping more than $40 million of extra money into the *Centaur* program in an all-out effort to prevent further loss of time in developing the first American launch vehicle in the same league with the big Russian rockets.

The NASA-Convair *Centaur*, now scheduled for its first flight test in the fourth quarter of this year, will have an orbital payload capacity of 8500 lbs., and will be able to send 1500 lbs. on an interplanetary mission—compared with the 1400-lb. weight of this year's silent Soviet Venus probe.

Difficulty with the simultaneous start of the two LOX-liquid hydrogen engines of the *Centaur* upper stage has caused slippage of several months in the first launch—which at one time was scheduled for June. The problem has caused three explosions at the Pratt & Whitney engine development center in West Palm Beach, Fla.

The two engines must start within milliseconds of one another. Otherwise, hydrogen and oxygen soon build up to an explosive mixture in the closed chamber used for engine tests. A closed tunnel with a soft vacuum is used for the tests to simulate the *Centaur* engine problem of starting in space.

Ironically, the explosions would probably not take place in a true space environment because the hard vacuum of space would draw excess hydrogen and oxygen away before the condition could build up. However, the problem still must be solved to attain reliable engine performance.

The trouble in the *Centaur* engine program came to light very recently. Until late in 1960, officials of the National Aeronautics and Space Administration said, the engine program at Pratt & Whitney was proceeding very well.

In its request for 1961 supplemental budget funding for *Centaur*, NASA said $13.9 million was needed to speed vehicle development and $2.3 million was needed for system support. No money was sought for engine work. The engine problems developed subsequent to submission of the supplemental request. Liberal additional funding for the engine work is included in President Kennedy's recent request for an add-on of $25.6 million for *Centaur*.

In testimony before the House Appropriations Committee Feb. 16, Maj. Gen. Don R. Ostrander, director of NASA's launch vehicle programs, estimated that the total cost of *Centaur* development and launching 10 vehicles by 1963 would be from $170 to $180 million. The additional cost of the engine program will probably bring the figure to about $190 million.

Col. Donald H. Heaton, Ostrander's vehicle chief, said in an interview that Pratt & Whitney had several proposed solutions for the start difficulty. He predicted that the problem will be solved by mid-year.

The overall problem on the *Centaur* program has been that it pushed the state of technology every step of the way, he said. Previous experience in the use of supercold (—428°F) liquid hydrogen as fuel was limited to research programs. And, to complicate matters, LOX and liquid hydrogen are not hypergolic. An ignition system is required.

"It is a pioneering development," Heaton says, "an effort to gain payload capacity and precision through efficiency—to gain the utmost out of an ICBM first stage."

The early phase of development progressed almost too smoothly, Heaton commented. There were few signs of trouble until the first attempt to fire the two engines last November.

The difficulty was not in ignition alone, he said. The *LR-115* bootstrap system ties everything together. Liquid hydrogen is used for regenerative cooling of the nozzle and the resulting gas drives the turbopumps. Electric spark ignition is used.

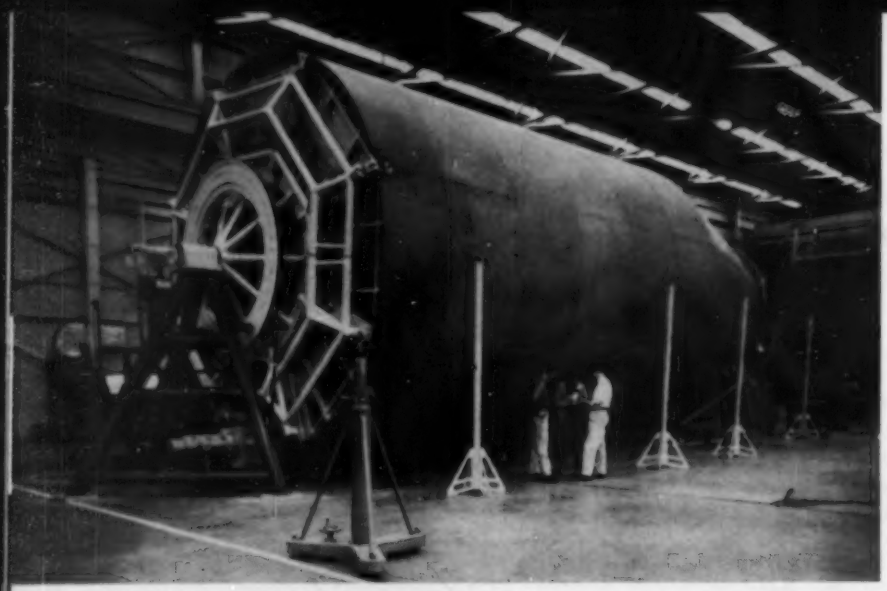
The problem, Heaton explained, is achieving buildup of pump speed, and thrust at exactly the proper rate to be in phase with the ignition. "This is no insuperable obstacle," he asserted, "but we have reached a point where we have to build up effort."

Pratt & Whitney has been authorized unlimited overtime since November, he reported. But additional money will speed the rate of testing.

From at least one point of view, the delay is not all black, the vehicle expert commented. The postponement of the launch makes it possible to do a more thorough job on other phases of the work. These include the study of heat transfer and foaming of liquid hydrogen under zero-G conditions. The supplemental budget funding includes money for four Aerobee rocket flights to investigate the problems. Zero-G tests with aircraft are in progress.

At the moment, NASA officials foresee no special problem in mating the *Centaur* stage to the modified *Atlas*. They note that the *Centaur* program, coming later than other *Atlas*-based vehicles has the benefit of experience gained in earlier programs. Also, the *Centaur* stage is the same diameter—10 ft. —as the *Atlas*, giving it an aerodynamically clean shape.

"We are meticulously holding to a policy of adequate design margins," says Cmdr. William Schubert, NASA chief of *Centaur*-class vehicles. "There will be no slicing of the baloney thin." ¤



DUMMY S-IV STAGE will fly atop Saturn booster in first three launches, beginning this summer. Configuration is changed from four LR-119 engines to six LR-115's.

(Continued from page 16)

vehicles 2, 3 and 4—were set for 1962. No. 4 is to be the first with live second stage, if the first three launchings take place without major difficulty.

Five launchings now are planned for 1963: three with two live stages and two with all stages live. The last two are scheduled for the first half of 1964.

Richard B. Canright, chief of *Saturn* class vehicles in NASA's Office of Launch Vehicle Programs, says the delays to date have been of a managerial nature—"having everything at the right place at the right time, proved out."

• **Few headaches**—But Canright declared in an interview that the number of problems encountered to date has been far smaller than anticipated. "When we started in 1958," he remarked, "there were skeptics all over the country who predicted an eight-engine cluster would never work."

Very few problems were encountered in the two series of static tests with the prototype booster last spring and this winter, Canright said. In the first series, the only problem was with nitrogen used to pressurize the LOX at the test stand. It had a tendency to heat up the LOX and boil it away.

That headache disappeared in the second series, which pressurized LOX with gaseous oxygen, just as in the flight booster. In that series, there was a small problem of burbling at the bottom of the LOX tank as the supply approached exhaustion. The first solution attempted was a small standpipe, but that burbling continued around the standpipe opening. It was solved by putting a "hat" atop the the pipe. Canright said future flight boosters will probably eliminate the pipe, leaving the "hat" atop a drain at the bottom of the tank.

The only other difficulty that developed during the winter tests was a focusing of the sound from the test in some areas of Huntsville. Because of this situation, the fourth test had to be postponed about a week until the weather cleared. Study of the phenomenon revealed that temperature inversion creates a greater problem than low cloud ceiling.

It was expected that six to eight firings would be necessary in the winter series. However, only four were needed and the series was completed with a 110-sec. firing Feb. 14.

• **Barge cruise**—The prototype booster was then taken down from the stand and put aboard the barge Palaemon for its shakedown cruise. The first flight booster now has been erected in its place and static firings will begin in a few weeks. After completion of static tests, the booster will move over to the dynamic test stand, now near completion, for a final check on the mating with dummy upper stages.

Then will follow the long voyage aboard the Palaemon, down the Tennessee, Ohio and Mississippi rivers to the Gulf of Mexico, around the tip of Florida and up the coast to Cape Canaveral. The present schedule calls for launching from the Cape in late summer—probably September. The three stages are to be delivered to the Cape by Aug. 1.

Meanwhile, assembly of the *Saturn 2* booster is in progress at Huntsville. *Saturn 2*, also carrying dummy upper stages, is to be launched in the first quarter of calendar 1962. Assembly of the booster for *Saturn 3* is to begin in July. Assembly of the booster for *Saturn 4*, the first to carry a live second stage, will begin in December, 1961.

Saturn 10, to be launched in mid-1964, is listed as an operational prototype and the last vehicle in the development series. However, earlier *Saturns* probably will be available for carrying payloads on a space-available basis. If all goes well, Canright says, it may be possible to carry a payload of up to 10,000 lbs. on *Saturns 8* and *9*, in late 1963 and early 1964.

If the design of the *Apollo* three-man spacecraft is established enough by that time, there is some talk of carrying dummy *Apollos* on *Saturns 6* and *7*, which are to be launched in mid-1963.

It will be possible to achieve orbit with only two live stages, on flights 4 through 6. However, since the three flights are designed only to prove out the two-stage vehicle, it is not likely that all three will be programed for orbit.

Canright emphasized that failures are to be expected during the development program. "If we can get successes in 5 of 10 shots, it will be a pretty high ratio," he declared.

On the first three flights, Canright said designers will be watching for trouble in two areas: the effect of high-altitude winds on bending and twisting of the vehicle frame, and the effect of propellant leakage in flight. Leakage has caused no trouble on the ground.

When flights begin with live upper stages, the whole question of liquid hydrogen technology will come up. However, the problem will be simpler with the *S-IV* stage, the first to fly, because no coasting or attitude control is expected of it.

• **Guidance question mark**—NASA still has not resolved the questions about the *Saturn* guidance system, Canright reported. However, under current thinking, there is no plan to choose a manufacturer as prime guidance contractor during the research and development phase. Instead, the idea is to procure platforms and computers from different manufacturers and evaluate them on developmental flights.

At present, Canright said, four different combinations of computer and platform are under consideration. Within the next few weeks, Marshall SFC expects to reduce the number to two. One will be a modification of the *Jupiter* system, now supplied by Ford Instrument Co. The *Jupiter*-type system will ride as a passenger on *Saturn 3*. The other computing system will probably be tested on *Saturn 4*. The choice will be made after evaluating data from those two flights.

There is no resolution of the discussions about the relationship between *Saturn* guidance, to be developed by the Marshall Space Flight Center at Huntsville, Ala., and the guidance on lunar and interplanetary spacecraft, to be developed by Jet Propulsion Laboratory. However, top NASA officials have no serious objection to a limited amount of overlapping. ⌗

Actual X-15 Altitude: 32 Miles Plus

Record 'cliffhanger' trip by Walker also set mark for experience in weightless state; cabin pressure system and engine fail briefly; mysterious shaking

REVISED NASA figures show that the altitude record-setting flight made by pilot Joe Walker in an *X-15* rocket plane reached 169,600 feet—4600 feet more than the preliminary figures indicated, and 20,000 feet better than called for by the flight program.

The new mark brings the world record to better than 32 miles above the earth. The flight also extended the known limits of man's experience of weightlessness to two minutes, doubling previous flights. Subsequent flights this spring will bring this to about five minutes in the *X-15*, and six minutes in the first *Mercury Redstone* astronaut launching.

Pilot Joe Walker described the latest *X-15* flight as a "real cliffhanger all the way." About seven minutes before *X-15* launch time, his cabin pressure system failed. A NASA spokesman said he was at low enough altitude so that his pressure suit system was not employed, and the cabin system was corrected.

After dropping from the B-52 mother ship, the *X-15*'s huge Thiokol XLR-99 engine suddenly faltered. After a few seconds interval—which Walker termed "like five hours"—he started it up again with no trouble.

Walker reached a top speed of 2756 mph recorded after 79 seconds burning at three-quarter throttle. He shut down the engine at 109,750 feet, and coasted to top altitude. His speed at top altitude was 2362 mph.

During descent, Walker noted that the ship was severely "buffeted" at about 80,000 feet. NASA officials were at loss to explain the phenomenon. The ship was undamaged and the shaking soon ceased.

The *X-15* flight took Joe Walker to about 99.97% above the earth's atmosphere. The *Mercury Redstone* shot, although planned to reach more than three times the *X-15* altitude of 32 miles, will carry the astronaut only 99.9999% above Earth's atmosphere. ⌗

NASA PILOT JOE WALKER smiles as he leaves X-15 after record-breaking ascent.

Said Gaspard de Coriolis: *"A particle which is subject to no forces in a rotating coordinate system experiences a radial acceleration and a tangential acceleration."*

It was around 1840 that Coriolis discovered what has since become known as the Coriolis Effect. He noticed objects above the earth tend to rotate relative to the earth's rotation . . . to the right in the northern hemisphere, to the left in the southern.

The Coriolis Effect is in force in outer space, too. If a space vehicle is rotated in order to establish artificial gravity, the necessarily short radius of the rotation causes a Coriolis force. This creates orientation problems for a human occupant. To eliminate this difficulty, a scientist at Lockheed Missiles and Space Division conceived the idea of connecting the vehicle to an auxiliary fuel tank by a half-mile-long cable. Thus, if the whole system is then rotated at a reduced speed around its center of mass gravity, the longer radius greatly minimizes the Coriolis force. Right now—on the drawing boards at Lockheed—is an enormously advanced space vehicle system which utilizes this concept, in addition to many others.

Fortunately, natural laws are about the only restrictions which circumscribe scientists and engineers at Lockheed Missiles and Space Division. The climate in Sunnyvale and Palo Alto, on the San Francisco Peninsula, is close to perfection. The creative atmosphere—the opportunity to work on such important projects as the DISCOVERER and MIDAS satellites, the POLARIS FBM, or even more advanced concepts such as the space system cited above—is the dream of the creative engineer.

Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-11C, 962 West El Camino Real, Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for the Navy POLARIS FBM and the Air Force AGENA Satellite in the DISCOVERER and MIDAS Programs

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA • CAPE CANAVERAL, FLORIDA • HAWAII

Technical Countdown

ELECTRONICS

Solar-driven Laser in the Works

A contract to develop and build a prototype sun-powered laser system has been awarded American Optical Co. by Air Force, WADD. Reportedly the system is for eventual use in long-range space vehicles for optical communications. AO also will build the solar-radiation collector for the working model.

'Gridded' Solar Cells More Efficient

Production-run solar cells with efficiencies up to 13% have been put on the market by International Rectifier Corp. Improvement is due to better collection of current by use of secondary collector strips "gridded" over the active area of the cell.

EIA Forms Microminiature Components Group

A microminiature components advisory committee has been set up within Electronic Industries Association. The group will advise on user recommendations for microminiature components for all applications. Its function was previously limited to computer applications.

Better R-f Connectors Aim of NBS

Bureau of Standards is sponsoring a meeting aimed at reducing errors in precise measurements due to r-f connector "uncertainties." It's hoped that the one-day meeting (June 29, Boulder Laboratories) will lead to standardization of a minimum number of connectors for use in laboratories and incorporation in precision instruments.

Thermionic Reactor APU Facility Started

General Electric's Atomic Products Division, Palo Alto, Calif., has established a project for the design of small nuclear conversion power units for space vehicles. Known as STAR (for Space Thermionic Auxiliary Reactor), the project is totally company-sponsored. GE says it will merely work toward design of such an electrical system, not build a prototype.

HYDRONAUTICS

Vaporborne Missiles Studied

Using a gaseous envelope around underwater missiles may double their speed, says Convair. Scientists at the division's San Diego facility so far have proved that much of the skin-friction drag of hydrodynamic bodies can be eliminated by such a vapor covering. It has been created in the lab by heating missile skins and by using body surfaces which react chemically with water.

SUPPORT EQUIPMENT

Linac Spots Fuel Flaws Faster, Deeper

Radiographs, employed to detect flaws in *Polaris* IRBM solid-fuel propellants, can now be made through the entire 5-foot thickness of the missile in 2 minutes, using a new 10-million-volt linear accelerator. Built by Varian for the Naval Ammunition Depot, Concord, Calif., the instrument replaces 2-million-volt X-ray units that required 15 minutes exposure time and penetrated only 2½ feet (film was placed inside the rocket-engine bore). The new linac can detect flaws of a few hundredths inch diameter, Varian reports, and cracks 1 in. by 0.005 in. have been located through 4 feet of propellant.

Antenna Loses Reflector

A 60-ft. antenna at Lincoln Lab's Millstone Hill banged into its base and separated the dish from its mount. Described only as part of "radar and communications facilities", the antenna was reportedly for use with Project *Needles*—the proposed orbiting belts of metal fibers for scatter communications (M/R, Sept. 19, 1960).

Venus Probe Uses Simple Telemetry

Russia's recent Venus probe apparently carried an unsophisticated telemetering system with only four data channels: temperature, magnetic field intensity, meteorite density, cosmic radiation. A drawing of the 922.8-mc system indicates that a simple mechanical commutator was used.

Lightweight Minuteman Hoist

Emplacement hoist developed by Western Gear for *Minuteman* is required to meet a 38-ton operating load and 50-ton static load, without weighing more than 1875 lbs. itself.

ADVANCED MATERIALS

Exotic Bearings Operate at 1000°F

SKF Industries has been running experimental bearings at 1000°F and higher, using powdered lubricants fed in by a stream of nitrogen gas. Bearings and seats are fabricated on production equipment from carbides, ceramics and other specially developed heat-resisting alloys.

Space Surface Effects Surveyed

The mechanical behavior of structural materials subjected to vacuums of the order 10^{-10} mm Hg will be investigated by National Research Corp. under a $49,520 Air Force contract. Pressure range is equivalent to altitudes beyond the 500-mile mark.

USSR Studies Electron-Beam Zone Refining

Single crystals of molybdenum, tantulum, rhenium and other refractory metals are being zone-refined with a laboratory electron beam unit, says Russian metallurgist A. N. Nesmeyanov, president of the Soviet Academy of Sciences. He also reports that a physico-chemical theory of designing metal alloys has been developed, making it possible to obtain alloys with predetermined properties.

Tartar's Director Is Outstanding In Field

by Hal Gettings

A NEW APPROACH to missile director design has paid off in increased accuracy, reliability, and performance for the Navy's *Tartar* ship-launched missile.

The *Tartar's* unique Mk73 director, built by General Electric Ordnance Dept., uses a gearless power drive in combination with a high-precision servo system to provide speeds, accuracies, and operating smoothness previously unattainable in such systems.

The *Tartar* is guided by a radar beam from the director which locks on and tracks the target. The director is thus a critical element in the overall weapon system; it must be able to track supersonic aircraft or missile targets at high speed with pinpoint accuracy.

The Mk73 is part of the complete system that guides the supersonic *Tartar* to its target. It serves as the mount for the AN/SPG-51 radar antenna and part of its electronics.

In operation, the system automatically follows a complex routine to acquire a target and guide the missile to the kill:

—Weapon detection equipment designates the target to the computer, radar and director, and the latter two synchronize to the signal.

—Computer generates a search pattern which director and radar follow until target is acquired.

—Radar and director commence tracking.

—Computer generates fire-control data and transmits gun and missile launcher position orders; also provides missile-seeker angle data.

—Missile is launched and follows radar beam to target.

• **No power gearing**—Principal unique feature of the Mk73 design is the gearless power drive, developed as an answer to the problems of gearing backlash, resonance, and inertia. GE engineers felt the real solution to the problem was not higher quality gears and precision gear trains, but the elimination of power gearing itself.

In the Mk73, the stator of the train (azimuth) motor is a part of the base of the director; the rotor is an integral part of the upper, rotating portion of the director. A similar system is used for the elevation power drive.

GE says that in addition to eliminating gear trains the gearless power drive provides unparalleled low-speed smoothness, high servo loop gains, mechanical simplicity, low power consumption, and a compact contour. The precision positioning obtainable with the device is described as unexcelled in the field.

• **Advanced servo system**—To take full advantage of the gearless drive, it was necessary to create an advanced servo system for the Mk73. This power-drive servo system, designed for extremely high precision, uses gyro-generated rate response to determine error signal. An angular accelerometer is also attached to the load to provide a velocity-damping degenerative feedback.

• **Rigid lightweight structure**—Because of the high gain characteristics of the servo system, it was necessary to eliminate all factors which could contribute to servo-loop oscillation. Sensitivity of the system to low-frequency vibration was particularly critical, and the reinforcement of any such vibration had to be eliminated.

To solve this problem, all structural members were designed to have resonant natural frequencies in excess of 20 cps. This was achieved through an exacting stress analysis and the integration of all motors into the structure. In the case of the direct-drive train motor, the rotor is part of the rotating structure and the stator yoke forms the major portion of the main load-supporting base, eliminating the weight of gear boxes and bull gears.

Design requirements of rigidity and lightness also presented a fabrication problem. New techniques of welding had to be devised to prevent warping of the thin-wall fabrications. Many components had to be cast to assure the proper strength. And the problem of mating aluminum with steel parts had to be solved.

The director was designed for 0.5-mil accuracy in the alignment between principal axes. Precise machining produced parallelism and flatness tolerances of 0.001 in. on surfaces larger than 40 in.

GE says the resulting Mk73 design exceeds all requirements in its ability to withstand adverse loading and fluctuating axial torque. The director can sustain 100-knot winds and blast loading equivalent to 50,000 lbs. of force on the radar reflector.

• **Special gear and bearing design**—Although the director uses no power gearing, precision instrument gearing is required for data transmission. The initial data take-off is from a ring gear operating at load speed. This gear, for train, has maximum tooth-to-tooth error of 0.0003 in. and total composite

GEARLESS POWER DRIVE eliminates all power gearing, with its problems of backlash, resonance, and inertia. Stator of train motor (bottom) is part of director base; rotor is integral part of upper rotating portion.

error of 0.0008 in. with a pitch diameter of 37.200 in.

The train bearing is designed to carry all loads between rotating and stationary parts of the director. A specially designed 4-point contact-type bearing was chosen to carry vertical, radial, and over-turning loads. This bearing proved to be extremely smooth in operation and offered a minimum amount of friction. The bearing races are held concentric with the mounting surfaces within 0.003 in., with runout no greater than 0.0005 in. The bearing diameter, approximately three feet, must withstand 50,000 lbs. thrust and 250,000 ft-lbs. of over-turning moment.

• **Braking and buffering**—Elimination of power gearing in the Mk73 required a means of load-speed braking the rotational motion of the director in the event of no-load operation. To meet this requirement, an adaptation of an aircraft landing brake, operating at load speed and capable of holding against 2000 ft.-lbs. of torque, was used. The system is hydraulically released and spring-set with quick response time for fail-safe operation.

Since director train rotation is unlimited, several devices and circuits were designed to prevent runaway without damage to the equipment. A buffer system was developed to restrain the antenna system under runaway conditions which require dissipation of up to 300 slug-ft.^{2} of inertia.

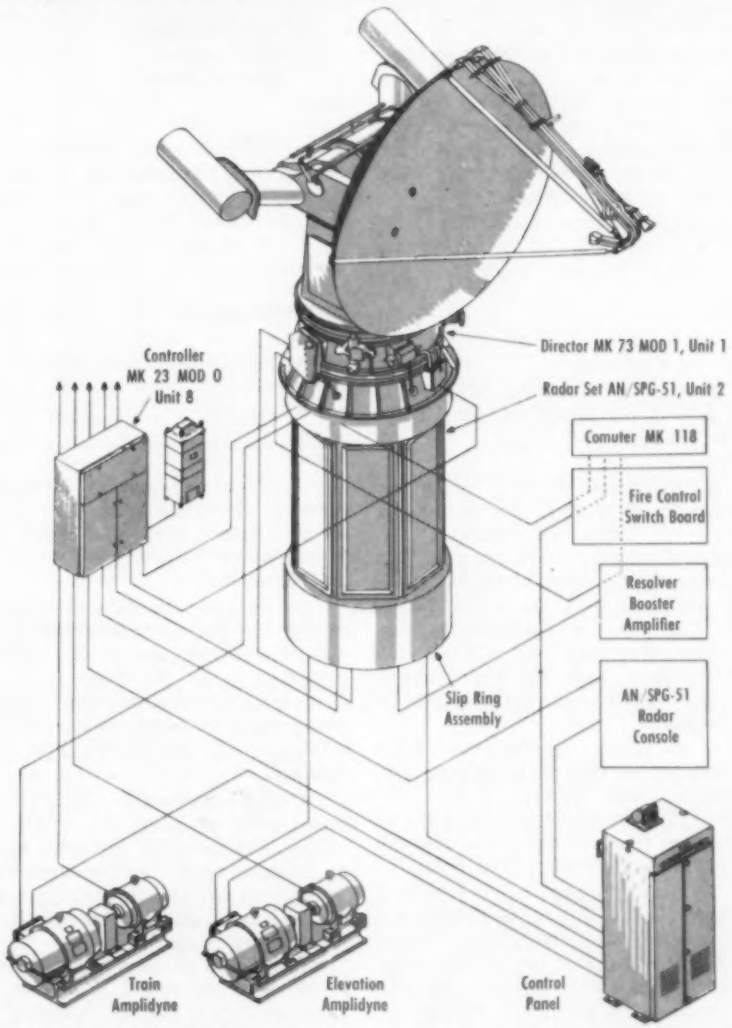
• **Safety, cooling and packaging**—Potential radio-frequency radiation hazards to personnel dictated that the director be unmanned. However, since operating technicians must be able to see from the vantage point of the director, it was necessary to install a remotely controlled TV camera in the director.

Air from the ship's ventilating system is ducted through the director to cool motors, wave-guides and other heat-producing devices within the unit.

Throughout the development and design of the Mk73, a primary consideration that the entire unit be kept as compact as possible. One of the most difficult problems was in packaging the wave guides so that they fitted in the director without impairment of electronic characteristics.

Although work was started on the director concurrently with all the other major subsystems, the Mk73 was completed and operational before any of the other components. ⌗

MISSILE DESTROYER ADAMS (DDG-2) was first Navy ship to be armed with operational surface-to-air Tartar. Mk73 directors (circle) track target and furnish radar beam which guides missile to interception.



GUIDED MISSILE DIRECTOR Mk73 is unmanned, amplidyne-controlled, two-axis unit which carries radar antenna and portion of electronics. Radar line-of-sight can be rotated continuously in horizontal (train) and from −30 to +85 degrees in vertical (elevation) plane.

Key to survival?

Kennedy Seeks Record Spending for Oc

Administration program would nearly double last year's budget funding; good prospects seen for compromise of Senate, House legislation

PRESIDENT KENNEDY is pressing Congress for unprecedented funds for oceanography because "our very survival" could be at stake.

Calling for a national program, the President has asked Capitol Hill to provide $100 million for oceanography —nearly double the amount in last year's budget, $23 million more than former President' Eisenhower's Fiscal Year 1962 request, and by far the largest sum proposed for this purpose in the nation's history.

In a special message sent to Congress on March 29, Kennedy declared that "Knowledge of the oceans is more than a matter of curiosity. Our very survival may hinge upon it."

The Chief Executive said that so far the U.S. has neglected oceanography, even though its study would yield important military advantages. "We do not have adequate charts of more than one or two percent of the oceans," he reminded Congress.

A major oceanographic bill is pending in both the Senate and the House, each measure authorizing a national program.

A bill offered by Sen. Warren G. Magnuson (D-Wash.), chairman of the Senate Committee on Interstate and Foreign Commerce, calls for a 10-year program during which about $600 million would be spent on oceanography. His committee is currently holding hearings on it. Last year, a similar bill by Magnuson passed the Senate unanimously, but its counterpart languished in the House.

In the House, the Chairman of the Committee on Merchant Marine and Fisheries, Rep. George Miller (D-Calif.), told MISSILES AND ROCKETS he is hopeful that hearings on his bill will be held before the end of the month.

"I think the chances of passing a compromise bill during the present session of Congress are very good," Miller said. He added that his bill and Magnuson's do not differ greatly, and both are in line with Kennedy's message.

A three-part program comprises the Administration's recommendations: (1) Substantial early investments for building and operating ship and shore facilities for oceanographic research and surveys. (2) Developing new instruments for charting the seas and gathering data. (3) Training new scientific manpower.

To do this, the Administration is calling for the coordinated efforts of many federal agencies. In fact, enabling legislation to let the Coast Guard do oceanographic research—which statutes now prevent its doing—is in each Congressional bill and in the President's message.

• **Ship construction**—In the Administration program for 1962, $37 million is included for ship construction, an increase of $23 million over 1961. This money will provide for 10 oceanographic vessels, only two of which will be replacing existing ships.

The success of the national oceanographic program hinges heavily on the construction of modern, specially designed vessels. The country's present oceanographic fleet has only 27 research ships and 17 survey vessels. Many of these are over 30 years old, and all but two of them were built before the end of World War II. Also, only two of these ships were specifically designed for research purposes.

• **Facilities and data center**—Shore facilities are critically needed to provide the laboratory space to analyze oceanographic data and to train new oceanographers. A rule-of-thumb figure is that oceanographic research takes about five scientists and technicians ashore to match one aboard ship.

Thus for 1962, the Administration is requesting $10 million for laboratories and wharfside facilities. This is more than a fivefold increase over 1961.

One deficiency filled by Congress last year was establishing the National Oceanographic Data Center, which will begin its first full year of operation in 1962. This Center will act as a clearing house to the scientific community for oceanographic data collected throughout the world. In 1962, a half-million dollars is being budgeted for this work.

• **Research money**—To conduct research on a coordinated and efficient basis is the chief purpose of the national oceanographic effort. For this reason, the proposed budget includes $41 million for basic and applied research. This is almost a one-third increase over the 1961 level.

This money will be used to study problems such as sound propogation in water, effects of ocean conditions on movement of ships, and better ways of weather forecasting. Eventually, this work may lead to maps of "weather within the sea" just as we have maps of weather in our atmosphere.

National Oceanographic Program Budget

Summary by Federal Agency

(thousands of dollars)

	Actual FY 1960	Estimated FY 1961	Estimated FY 1962
Defense	23,003	22,729	32,837
Commerce	6,202	11,389	24,691
Interior	6,723	8,704	15,472
National Science Foundation	7,833	9,148	19,607
Atomic Energy Commission	1,708	2,207	3,619
Health, Education & Welfare	340	698	1,150
Treasury	134	134	134
TOTALS	45,943	55,009	97,510

Summary by Function

(thousands of dollars)

	Actual FY 1960	Estimated FY 1961	Estimated FY 1962
Research	26,577	31,883	40,947
Ship Construction	13,533	13,975	37,050
Surveys	4,168	7,117	8,725
Facilities	1,370	1,768	10,422
Data Center	295	266	510
TOTALS	45,943	55,009	97,501

for Oceanography

by William Beller

Knowing the currents that run in the sea is highly important for the surface and submarine fleet. A 60-knot vessel running in a 6-knot current would have the same advantage as a 600-knot aircraft running in a 60-knot jet stream.

Extremely important to the research program is the development of oceanographic research tools. So vital does this work appear that Magnuson in his bill actually lists some of those that most direly need developing. He is calling for bathyscaphs and other manned submersibles, instrumented marine towers and deep ocean buoys, wave gages, acoustical equipment and telemetering devices, and current meters.

He is also asking for direct-density, turbulence and radioactivity measuring devices, biological sampling instruments and equipment, precision salinometers and echo sounders, magnetometers, and deep-sea underwater cameras.

• **Mapping the seas**—The Administration is calling for world-wide surveys of the oceans, their properties, their contents and boundaries—in order to make charts and maps for research and for defense and commerce. To help do this, Kennedy is budgeting money to allow the Coast and Geodetic Survey —which Congress last year permitted to go beyond the three-mile limit for oceanographic research—to extend the operating season of its ships, thereby making longer use of the limited ship resources.

MAP OF ARCTIC FLOOR derived in part from transits by U.S. nuclear submarines.

• **Defense applications**—The naval officer is again and again confronted with transient and subtle changes in the ocean depths which always affect and often control the success of the service's weapons systems. Yet since World War II there has been no effort to improve research ships in this country. In the meantime, the Soviet Union has been pushing ahead in building oceanographic ships, making oceanographic studies and training their oceanographers.

"Only last summer that country had seven large research ships conducting intensive studies of the Gulf Stream all along our Atlantic coast," Magnuson says. He pointed out that during that time we had only three small research ships working briefly in the vicinity of Bermuda.

Every fishing vessel and trawler the Soviet sends out has its complement of highly trained oceanographers. This was brought out during the exchange of data stemming from International Geophysical Year research, and from conversations of our scientists with those from Russia.

Last year, the Soviet had research ships working in the Bering Sea, along the Aleutians and the Gulf of Alaska. Also during that period, it launched four new research ships, at least two of which had more than 3600 tons displacement. On the other hand, last year the U.S. had contracts for construction of only two research ships of about 1500 tons displacement to be completed in 1962.

The last and only ship outfitted for oceanographic research for the U.S. is the 298-ton *Atlantis*, built in 1931. All the other research ships are converted surplus naval auxiliary vessels, or aging ex-schooners, purse seiners, tugs, tuna clippers or similar craft.

Happily, as a result of the transits of the Arctic Ocean by nuclear submarines, the U.S. has advanced knowledge about the characteristics of that area.

Until the mid-40's, the general idea was that the floor of the Arctic Ocean was an abyssal plane unbroken from coast to coast and averaging about 2000 fathoms in depth. Later work by the U.S. and the Soviets shows these conclusions to be grossly in error.

One of the biggest boons to oceanography that a Magnuson-type bill can give is the impetus for planning scientific work on a long-term basis. Oceanographic research organizations continuously complain that the usual "on-again off-again" type funding they receive does not easily lend itself to serious work. #

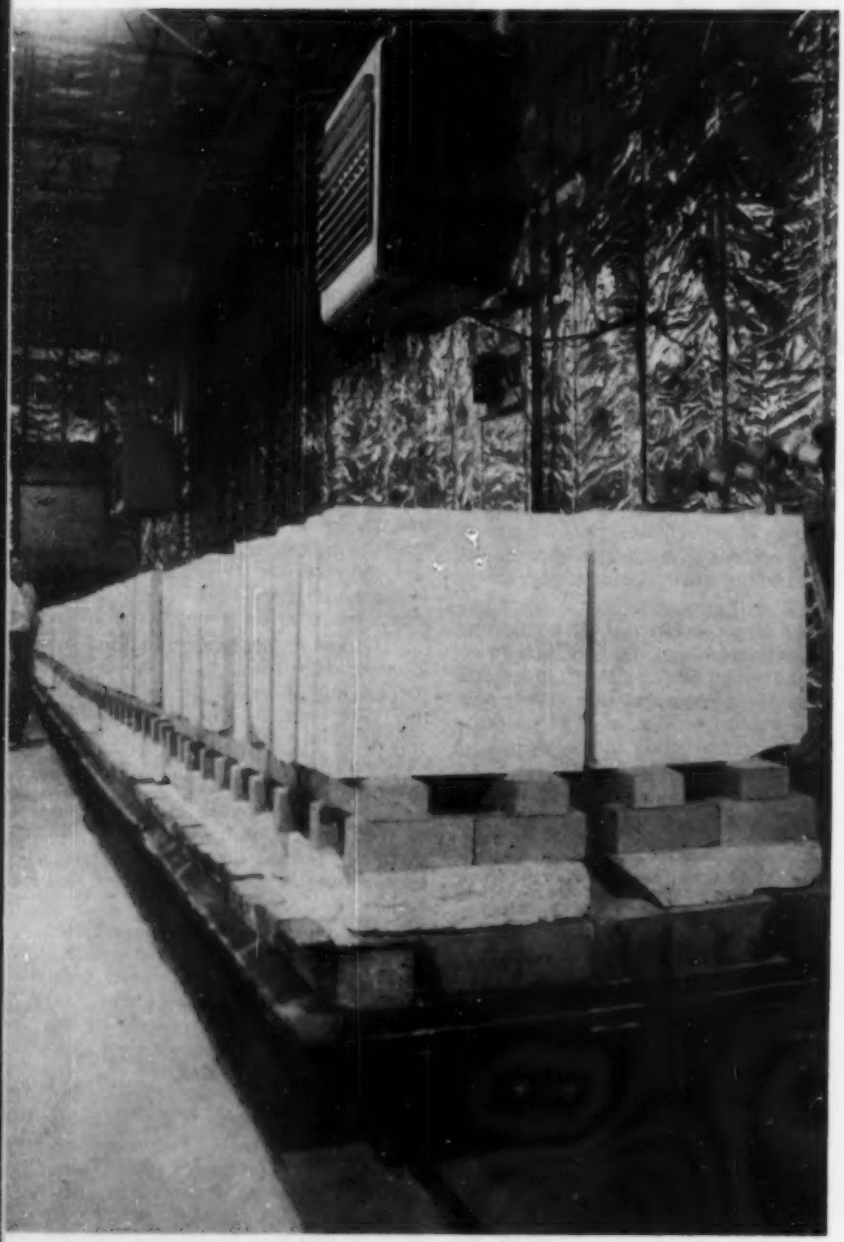
Bill S. 901, *introduced by Sen. Warren G. Magnuson (D-Wash.) on Feb. 9, 1961, calls for developing new and improved vehicles and instruments for ocean research and exploration. These may include, but are not limited to, the following:*

Bathyscaphs, mesoscaphs, self-propelled deep-sea data collecting vehicles, and other manned and unmanned submersibles, and submarines converted for scientific use, seismic equipment, turbulence measuring devices, oceanographic sound velocity meters, precision echo sounders, acoustic telemetering devices, navigation location transponders, audiovisual surveillance systems to monitor sources of biological noises in the ocean, submarine oceanographic plankton samplers, hydrophotometers, fixed coastal acoustical-oceanographic monitoring systems, marine geophysical gravity meters, marine geophysical electron resonance magnetometers, shipboard wave meters and dye detector probes, marine geophysical remote sensing and recording systems, moored oceanic ambient noise monitoring buoys, expendable oceanographic sensor systems, oceanographic sonic and radio frequency marine tags for monitoring marine fishes and mammals, improved midwater trawls, oceanographic shipboard synoptic systems for use on weather ships, marine radioactive water samplers, shipboard gamma ray detectors, marine geophysical underwater cameras, geophysical sea floor television systems, sea floor sediment samplers and analyzers, sea floor dredge winches, and other such instruments, devices and systems as may be useful in studies of the current structure of the ocean, oceanic temperatures, bottom topography, sediments, heat flow through the ocean bottom, sound transmission and velocities, ambient noise, biological activity and specimens, water samples for salinities, phosphates, oxygen, nitrogen, and other chemical or elemental components of the oceans, and for recording and communications of oceanographic data.

Glasrock Applications Described as Li

Uses of highly shock-resistant ceramic family have been studied at Georgia Tech since '56

by John F. Judge



BLOCKS OF GLASROCK FOAM roll out of the curing kilns. These blocks are a major constituent of massive brazing and stretch forming fixtures.

ATLANTA—A family of ceramic materials characterized by extraordinary shock resistance and ease of fabricability is stirring interest throughout the missile/space industry.

Produced by Glasrock Products, Inc., the material has applications ranging from ablative nose cones to the massive tooling and brazing fixtures required to shape tough Space Age metals.

The ceramic starts with 99.9% pure silica sand. A unique melting process developed by John North, president of Glasrock, converts this into lumps of fused quartz. The quartz is then ground or crushed to obtain "Glasgrain" and "Glasflour," the basic material of the family.

From this comes "Masrock," dense aggregate castings with smooth faces; "Shelrock," dense slip castings with smooth faces; "Glasrock Foam," light porous blocks; and "Glasrock" Cement.

The firm has expanded twice in as many years and is currently operating at top capacity to meet a rapidly increasing market.

• **Unlimited potential**—The Ceramics Branch of the Georgia Institute of Technology has been exploring the applications of Glasrock since 1956. J. D. Walton, Branch Chief, says "the potential uses of this material are essentially limitless, including such fields as nuclear, chemical, electrical and optical as well as ceramic and aircraft or missile industries."

Fused silica is a well-known substance. But Glasrock, while the same basic material, does not have the properties of clear fused silica. The material is crushed into fine particles and then cemented into shape. These shapes are formed at room temperature—not at 3100°F, as is clear fused silica.

The effect of pulverizing is illustrated by the difference in thermal conductivity. Clear fused silica shows a rapid rise above 300°F while slip-cast fused silica is a good insulator up to 2000°F.

N. E. Poulas, Assistant Head of Georgia Tech's Ceramics Branch, at-

as Limitless'

TYPICAL BRAZING FIXTURE illustrates one application of foamed silica blocks. Dimensional stability and thermal shock resistance are excellent.

tributes this difference to the transmission of radiant energy in the clear form and the diffusion of this energy by the particulate form. This factor is evident in the use of slip-cast silica reflectors for clear fused silica radiant heating lamps.

The low thermal expansion of Glasrock gives it high thermal shock resistance. A piece of Glasrock will remain intact through numerous cycles of immersion in molten iron with alternate cooling to near-room temperatures by water, or immersion in liquid nitrogen from 2000°F.

This characteristic is due to the many fine bonded particles which provide areas of thermal stress relief.

The bonded Glasrock is weaker than solid glass cast in the fused state. Glasrock normally has a modulus of rupture or flexural strength from 300 psi to 4000 psi. The electrical properties are essentially the same as fused glass, with allowances for porosity.

Chemical resistance has not yet been fully checked out. The firm recommends the material in dense compositions for trial in the same areas as silica glass—with the expectation that chemical soaking into the pores will be somewhat more active against individual grains than solid glass. This is due to the greater area exposed. Generally it is highly resistant to chemicals on the acid side and fair for alkalies.

The melting point of Glasrock without binders is slightly over 3100°F. It is quite viscous above this point. Pieces of considerable size can be fused into stronger and practically impermeable bodies while supporting themselves against appreciable sagging.

• **Devitrification**—In refractory areas, the material has some special characteristics. Handbooks maintain that above 2000°F under prolonged or cyclic heating, fused silica will devitrify or crystallize into cristobalite, another form of silica. In an attempt to define the cycle effect, GPI engineers poured cast iron repeatedly into the same Glasrock mold, allowing the casting to remain there until it solidified. After repeated trials involving dozens of cycles, no devitrification was found. The same effect was checked with a laboratory furnace. It appears that if one cycle will not start the crystallization, then neither will repeated cycles under the same conditions.

One side of a Glasrock block was exposed to furnace temperatures while the other remained at room temperature. In this case, the hot side devitrified to near the point where the expected temperature reached 2000°F. The devitrified portions showed check cracking or crazing which commenced well after the sample had lost its color from the heat. The crystallized portion bonded firmly to the unaffected areas. This has also proved out under vibration conditions.

In the containment of ferrous metals, cristobalite has practically the same volume as silica glass above 1200°F. If the vessel pipe or valve is kept hot, devitrification is no problem. If cracking does occur because of cooling, it is necessary to preheat to 400°-500°F, which closes most of the cracks before the molten metal is poured.

General Electric's Missile and Space Vehicle Department is looking at Glasrock as part of the whole range of SiO_2 compounds from a laboratory standpoint. The effect of ablation tests on various structures and textures of this type of material are under study. GE scientists have doped it to change the emissivity.

MSVD specialists find Glasrock's fabrication qualities attractive. It can easily be slip-cast into intricate shapes at room temperatures. They find the material excellent for wind-tunnel models because of this easy fabricability.

• **Nuclear applications**—Glasrock is being actively investigated for certain reactor uses because of its thermal shock, chemical inertness and low-neutron-capture cross-section properties. In addition, radiation is actually beneficial—crystalline substances tend to vitrify under prolonged exposure. Glasrock materials are already completely vitrified.

All of these qualities are coupled with a product form that can be easily engineered. Complex one-piece heat exchangers have been fabricated.

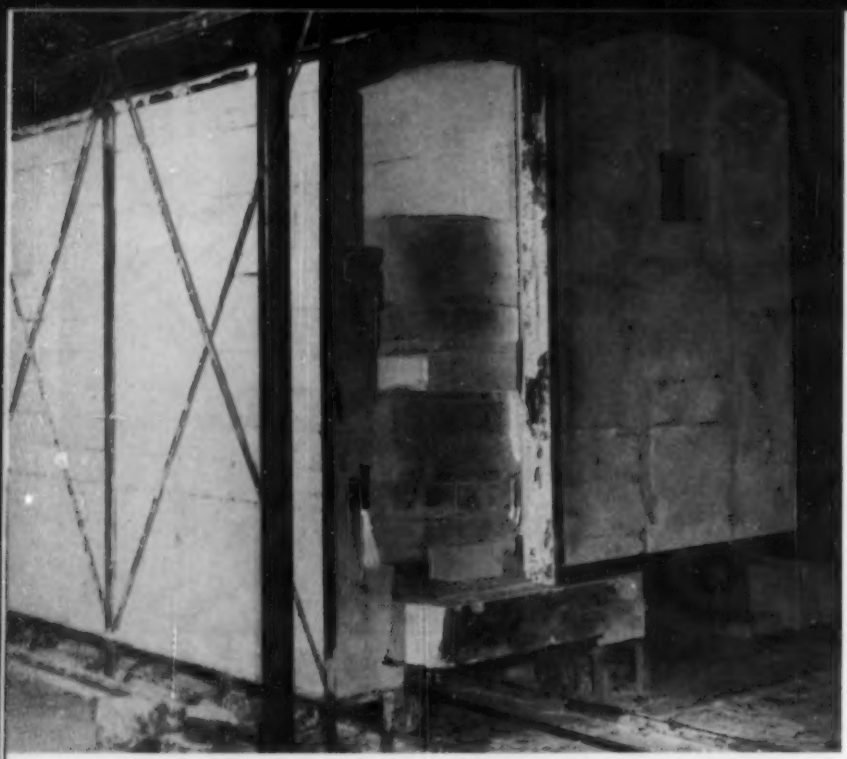
Probably the biggest single application of the material is in the fabrication of super alloys such as titanium and stainless steel. Within this general area are brazing fixture uses for honeycomb panels.

Convair-Fort Worth interest in Glasrock materials centers around stretch forms and brazing applications. Test tools have been evaluated to the point where production tools are being fabricated.

Convair is currently using gas-heated Meehanite stretch forms for production of titanium skins. These tools are expensive, requiring long lead times and much hand finishing to reach final configurations. Tool surface temperatures are not easily controlled.

A Glasrock tool, integrally heated by nichrome wire embedded in its face, can be fabricated at approximately ¼ the cost and, more important, tool surface temperatures can be controlled to within ±20°F.

• **Tough-metal forming**—Convair's fabrication technique begins with a female plaster mold, prepared to final configuration. A spacer sheet of rubber or epoxy is placed against the face of



LOW "K" FACTOR coupled with the high reflectivity of the foamed blocks used in construction of this inexpensive furnace makes the walls just warm to the touch—while containing temperatures up to 2000°F.

the plaster and a Glasrock cement-Glasfoam backup is built, filling the entire plaster pattern. The backup is allowed to cure until "green strength" is sufficient to allow the pulling of the pattern and spacer blanket.

Location holes for resistance heater wires are drilled in Dike boards which are cemented and pinned to the back-up. "Dummy" wires, oversize to actual heater wires and treated with a parting agent, are strung across the back-up and tied to the Dike boards.

The entire back-up is then repositioned in the original plaster pattern and Glasrock cement is cast in the void area created by removing the spacer. The casting is allowed to cure until the pattern can be removed. "Dummy" wires are pulled, a steel plate is attached to the casting as a base and the tool is ready for wiring.

Convair cites as advantages the relatively short fabrication time, the need for only semi-skilled personnel, the ability to cast to final configuration with no grinding or hand finishing, the absence of any need for lengthy high-temperature cure, the easily controlled surface temperatures and complete freedom from thermal shock effects.

Among the disadvantages are the relatively high cost of Glasrock materials, the fact that their poor impact resistance and low flexural strengths create a need for caution in handling and storage, and a tendency of the surface to be abrasive.

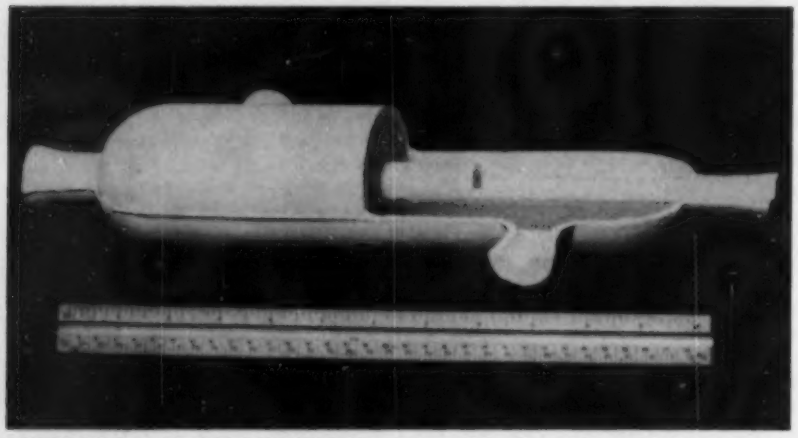
G. P. I. maintains that their ceramic compares favorably in cost with other tooling materials such as tooling plastic, Meehanite and graphite. The time and labor savings are above and beyond this.

Brazing fixtures at Convair are quite similar, except that these tools are not integrally heated. Cooling provisions are included. These tools are supported by steel structures which take most of the load.

Convair is evaluating both the two-member and one-member die concept of brazing. Male and female ceramic members are required for the former, with both members demanding extensive cooling facilities. Using only one ceramic tool, combined with a metal pressure bag built to the proper configuration, cuts tooling costs almost in half.

Through Glasrock, Convair eliminates the need for brazing furnaces—in addition to the advantages cited for the stretch forming process. On the other hand, Convair reports, the disadvantages are generally the same—including the high cost of fabricating the steel structure.

Almost all major missile/space firms are involved with Glasrock to some extent. North American Aviation has flatly stated that the B-70 could not be built without such a material. ⌗



FUSED SILICA HEAT EXCHANGER was formed by slip casting methods at Georgia Tech. The device grew out of a U.S. Bureau of Mines fabrication study.

Cost Cuts Expected from 100% Tungsten Castings

PURE TUNGSTEN is being melted and successfully cast into hollow-ring shapes by Oregon Metallurgical Corp., Albany, Ore. The development is expected to reduce the cost of production parts of the metal.

Ormet uses a cold crucible, skull-melting vacuum-arc furnace. The copper crucible is kept cool with water. The furnace is charged with 40,000 amps of power at about 40 volts d-c.

The castings are produced by centrifugal process in hollow-ring shapes up to 10 in. across and weighing up to 220 lbs. The pure metal rings have a finer grain structure than was heretofore attainable with arc-cast ingots. The melt is achieved in five minutes and pour must be made within four seconds.

Tungsten melts at 6170°F, but the exact temperature of the melt just prior to pour is not known.

One immediate advantage is that the expensive machining of tungsten ingots by rough hogging out the surplus metal may be eliminated. This method usually resulted in three 30-lb. products from a 1000-lb. ingot. ⌗

A Low-cost B-58 Defense Simulator

Air Force says Reflectone-built system, costing only one-hundredth as much as the aircraft itself, may be the most complete ever developed; sharp cut in training time is likely benefit

A REALISTIC SIMULATOR developed for Defense System Operators in SAC's B-58 supersonic bombers will save considerable time and money during training—without tying up much-needed aircraft and crews.

Designed and built by Reflectone Electronics, Inc., for the Air Force's Strategic Air Command, the first training complex is now in operation at Carswell AFB, Fort Worth, Texas. Reflectone reports that acceptance tests have just been completed on the first of four such systems being built under a current contract to Convair Division of General Dynamics.

Designated AN/ASQ-T1, the trainer includes an exact replica of the defense system station in the Mach 2 bomber. It provides flexibly programed enemy electronic detection as well as aircraft or missile target-generating stimuli, and has the ability to evaluate operator performance. An Air Force spokesman says the system is believed to be the most comprehensive ever built.

A complete system, according to Reflectone, costs one-hundredth the price of a B-58.

Initially, the simulator will be used 12 hours a day for orientation of new B-58 crew-members and transitional training. Eventual programs call for three intensive 6-hour proficiency training missions daily.

• **Operator functions**—The Defense System Operator (DSO) is responsible for protecting his aircraft from enemy detection and attack so that it can complete its assigned mission. Since the pilot and navigator of the B-58 are otherwise occupied, the DSO must monitor for tracking and possible attack. It is his task to command evasive actions or take necessary electronic countermeasures.

Use of the DSO simulator is expected to compress radically the time required for training B-58 crews in critical skills to peak proficiency. It can be operated independently or, for maximum value, interconnected with navigator and pilot trainers for coordinated aircrew instruction.

Interconnect inputs to the DSO trainer provide information which would be simulated normally during independent operation. These data include true airspeed, altitude, angle of attack, true heading, aircraft position (latitude and longitude), bailout signals, station beacon, and jamming information.

In turn, the trainer subsystem provides the flight simulator with certain signals and with commands for evasive action. Changing data received by the DSO station continuously affect the training problem.

System computers constantly adjust target attack or maneuver patterns, as well as positions of simulated ground-based radars, to coincide with the input positional data. The intercom system, tape recording, and certain training problem control functions also can be interconnected.

• **Composite design**—The system includes in one unit an isolated trainee station, duplicating the third crew station of a B-58, an instructor's station, recording equipment and associated instrumentation.

The system simulates ground radars and radar-equipped aircraft or missile targets. The student operator receives visual- and audible-alarm warnings of attack or detection; he must select evasive, ECM, or chaff techniques to combat the enemy threat.

Reflectone's simulator was developed to contain all the actual operating equipment necessary to train a DSO. Because of the critical nature and speed of skills required for B-58 operation, composite design was mandatory for proper training environment.

Training must be provided in the tactical use of active and passive defense systems, including fire control and ECM gear. Faithful duplication of operational environment also demands operator orientation in use of the canopy, ejection seat, oxygen and communications systems, fuse control and fuel management functions.

Visual stimuli such as lighting and fire control system display are simulated, along with aural stimuli such as flight sounds, radar warning signals and intercom.

• **Flexible programing**—A highlight of system design, Reflectone feels, is the flexible automatic programing system. This provides for presentation of either uniform or variable training problems, relieving the instructor of the mechanics of continuous trainer operations so that he can concentrate on monitoring the student response. The instructor's station contains both manual and automatic punch-tape equipment for controlling flight exercises.

The programer has a repeatable capacity of 50 training conditions such as radar warning, airborne attack or system malfunction. These can be activated at a maximum rate of one every 2 seconds for 10 hours, a total of 18,000 functions during a simulated mission far exceeding human reaction capability.

The instructor may freeze, interrupt, delay or repeat a programed mission sequence to critique and correct student responses and analyze problem areas.

Revising heading, position, altitude or speed references will alter the positions or ground return lines of simulated radars appearing on the student's instruments, as well as the attack angles, closing rates, and direction of attacking target aircraft or missiles. Course conditions inserted from the flight simulator similarly affect the problem.

• **Malfunction simulation**—The introduction of malfunctions and equipment failures likely to occur during actual flight can create realistic and frightening situations requiring analysis and hair-trigger response by the student. A myriad of typical malfunctions can be simulated; action required could range from use of emergency oxygen, to ignoring the warning lights or seeking causes of the indicated condition.

The student must constantly remain alert and utilize good judgment in the

emergency situations that are an ever-present reality of supersonic bomber operation.

• **Target simulation**—Of the many considerations involved in the design of the DSO Trainer target generators, probably most important, a Reflectone engineer said, was the requirement for a hybrid automatic-manual program control.

A completely programed or "canned" type of target generator bomber-control system was not acceptable, he recalled, because the simulated bomber had to perform evasive maneuvers involving speed and heading changes during a particular target run. The speed-change evasive maneuver is one of the major defenses of the B-58.

Further, the DSO instructor during independent mode of operation (or the student pilot in the interconnected mode of operation) must be capable of performing the exact evasive maneuver called for by the DSO student. The student is then able to monitor his flight control simulator display and see results of the specified maneuver.

A completely manual target generation system was not acceptable because of the lack of inherent realism and the additional load placed on the instructor. Also, a manual system could not provide the required repeatability for multiple-target attack patterns so that a particular attack pattern could be continuously presented for developing critical operating techniques. Finally, the same attack pattern must be presented to different students when the trainer is used to evaluate performance.

• **Variable targets**—Target programing is achieved by means of a Hickhock Cardomatic switch into which punched mylar cards are inserted. Target functions, programable for each of the three target generators, include 10 variable parameters.

Two target attack patterns are available: (1) The "pursuit" attack simulates infrared-homing missiles or a fighter aircraft following the pursuit attack pattern; (2) The second is the "lead-collision" attack which simulates a ballistic-type missile or a fighter aircraft flying a lead-collision course.

Target initial azimuth and target initial elevation (relative to specific aircraft axes) may be programed, as well as target initial range in 500-yard increments. Programed target speed in 50-knot increments is constant throughout the target run.

• **Targets and decoys**—Simulation of breakaway targets is achieved using programer card selections which cause targets to deviate from their pursuit or lead-collision path and fly-off, either right or left in ranges of from 0 to 4000 yards in 250-yard increments. When the target reaches the selected fly-off range, it turns right or left (as selected) at its maximum turn rate until it flies off the scope or until it reaches specific heading deviating from the bomber heading.

Decoy targets also may be simulated and made to deviate from the heading dictated by their pursuit or lead-collision course and fly a constant heading error.

The maximum performance rate at which a particular target will turn can be programed. Thus, if the pursuit or lead-collision path dictates a bomber turn rate or evasive maneuver exceeding the maximum turn rate of the target, the target will fly at its maximum turn rate, eventually flying off the scope, or until it is again on its pursuit or lead-collision course. A start-delay feature in each of the three generators may be used to delay time between initiation of each target from 2 to 30 seconds.

If the student correctly applies his ECM equipment to the attacking vehicle, the target will drift off the radar scope to simulate ECM success.

• **Controllable bomber parameters**—Non-programable bomber functions are provided in the trainer, so that bomber heading and speed may be changed at will during the target run to simulate evasive maneuvers. In the independent mode of operation, the DSO instructor has continuous control of bomber speed and is provided with an airspeed indicator and an ACCEL-DECEL switch for setting bomber speed and for performing speed change evasives. Rate of acceleration or deceleration may be set by means of a maintenance adjustment, and the instructor also has continuous 360° control of bomber heading.

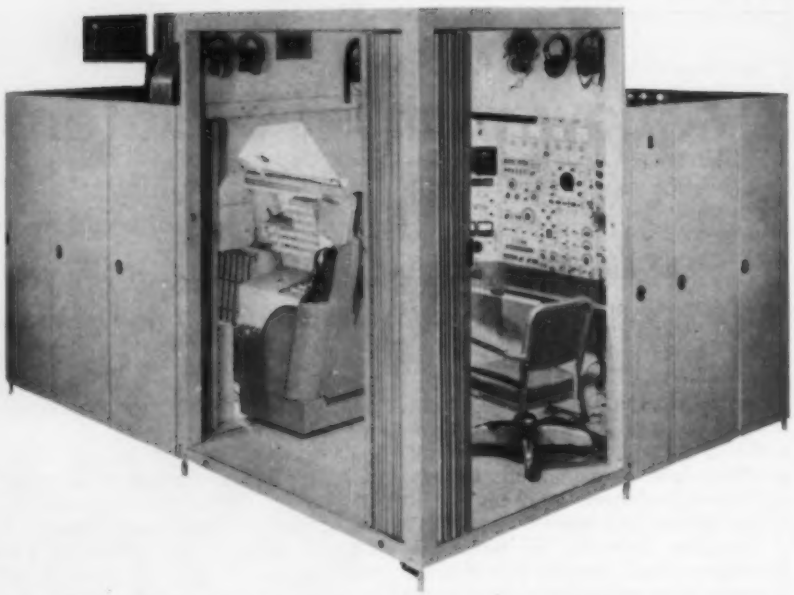
In the interconnected mode of operation, bomber heading and bomber speed are obtained from the flight simulator.

• **Bomber roll and pitch**—The radar antenna in the aircraft fire control system is not stabilized in either roll or pitch; thus azimuth and elevation position of a target signal on the radar indicator is affected by aircraft movement.

In the interconnected mode of operation, pitch and roll are taken from the flight simulator. The independent mode provides for bomber pitch to be taken from the instructor's climb-dive switch, and bomber roll from the instructor's right-left turn switch. Thus the instructor can accomplish the evasive maneuvers called for by the student during the training mission.

• **Computer design**—The analog computer employed in the simulation system is designed to produce pursuit or lead-collision attack courses, selected by means of the punched cards. In general, angular quantities are indicated by mechanical shaft positions and scaler quantities by d-c analog voltages.

The development of very accurate



B-58 DSO SIMULATOR, built for Convair by Reflectone Electronics, Inc., includes trainee's compartment (at left), instructor's console (at right). The system permits complete training of the Defense System Operator, who is in charge of performing evasive maneuvers and electronics countermeasures for defense of the Strategic Air Command's Mach 2 bomber.

REALISTIC CONTROLLED training situations are presented to student DSO's, their responses are recorded, and performance evaluated, automatically. The student's compartment is a faithful reproduction of the DSO station in the B-58.

elevation signals is not necessary; the only elevation indication in the radar system is the relative time sequence in which the several target signals flash on the "scope" indicator. This function is provided, however, with initial elevation set as a d-c voltage.

For a collision attack, elevation remains constant; for the pursuit attack, the elevation d-c is derived from a pursuit curve function potentiometer driven as a function of range.

• **Performance evaluation**—Scoring and evaluation techniques developed by Convair and Reflectone produced a design innovation which limits the amount of recorded information to "errors only." This procedure economically reduces analysis time, shows nature of errors in point of time during the mission, and permits faster instruction.

Real-time displays, duplicate controls and instruments, and switch position "tell-light" indicators make possible visual monitoring by the instructor. Student errors are recorded automatically and displayed until corrected. The reactions are recorded on paper tape, with voice commands or instructor criticism preserved on magnetic tape for later review.

The "Tel" system is the basis for all recording and visual observation of student performance. When the student and instructor switches are in positional coincidence, the instructor's tel lamps are extinguished and error signals are not fed to the recorder. If, however, the student's and instructor's switches are not in positional coincidence, the tel lamp corresponding to the student's switch position is illuminated and an error signal is applied to the appropriate recorder line.

The selective tel system operates with all student switches for which there is a proper or correct position at all points along the mission profile. This includes switches which are positioned according to preflight briefing as well as those which are positioned for mission events. The selective tel system monitors 22 individual student switches and 112 discrete switch positions.

In addition to the "selective" tel system, the instructor has a non-selective tel system which simply indicates the student's switch position. The non-selective tel system is applied to student switches for which there is not a proper or correct position at all points along the mission profile.

• **Mission programer**—An 8-channel punched-tape reader capable of handling tape for a 10-hour mission is used for programing. Individual items are programed to a time accuracy of ±2 seconds.

The eight channels provide the 50 separate activation switching functions by means of a relay matrix. Matrix outputs are so terminated as to allow each switching function to control more than one item. At the present time 96 functions are controlled by the programer, and the relay allows specific items to be changed readily.

The mission programer establishes comparison data for the selective tel system, initiates the six periodic recorder scans, inserts and clears malfunctions, initiates "fuse blow," bomber flight start, and airborne attack start.

• **Open-fuse simulation**—Since one of the vital functions of the DSO is to monitor major portions of the aircraft electrical system, the trainer contains a replica of the actual aircraft fuse banks containing over 400 fuses. Upon notification of a system malfunction, the DSO must locate and replace the inoperative fuse.

For training purposes, Reflectone developed a unique "mock" fuse with all the characteristics of an actual fuse, except that it can be "blown" at will by the instructor or programed tape and later reset for continuous use. The DSO operator must replace the fuse correctly from a supply of different "mock" fuses which are not exchangeable in rating. Insertion of an incorrect fuse will cause a malfunction and record an error.

• **Designed for the future**—In addition to the already comprehensive capability of the DSO simulator, its design includes provisions for retrofitting of the trainer coincident with changes in actual aircraft configuration, instrumentation or performance parameters. The installations, according to Reflectone, can be kept current with operational requirements or outfitted in advance of proposed changes to orient personnel. ⌗

Standards for Measuring Dial Brightness Available

BRIGHTNESS of aerospace instrument dials and panels can now be measured by standards provided by the National Bureau of Standards.

The luminance standard consists of two components: a diaphragmed flashed-opal glass and an electric lamp. Flashed-opal glass is used because its transmittance is reasonably high (about 50%) and uniform over a considerable range of angles.

The luminance standards are used to calibrate any type of photometer. The photometer may then be used directly to measure the luminance of achromatic light-diffusing surfaces. With a color-matching filter of known transmittance as an additional component, the photometer will measure the luminance of chromatic surfaces.

Standards cost from $63 to $72, depending on size of the lamp, and may be obtained from the Bureau's Photometry and Colorimetry Section, in Washington, D.C. ⌗

Big Switch to Glass-Plastic Cases

Range of Minuteman, Polaris and Pershing will be lengthened by changeover; trend is highlight of SAMPE meeting

by Frank G. McGuire

PASADENA, CALIF.—The ranges of *Minuteman, Polaris* and *Pershing* will be increased by completely equipping them with glass-reinforced plastic rocket motor cases.

Plans for the change-over were revealed at a symposium here of the Society of Aerospace Materials and Process Engineers. Although no one laid out timetables, there were unmistakable signs of a major trend in materials applications. Numerous programs in addition to *Minuteman, Polaris* and *Pershing* were alluded to, but not by name.

The symposium attracted more than 600 registrants representing every significant company in the glass, resins, plastics and filament-winding fields.

In addition to the switch from high-strength steels to composite materials in the major programs now underway, future applications for the new materials ranged from deep-diving submarines to ground support equipment, tanks for liquid-fueled rockets, radomes, and anything else capable of being designed around the properties of the glass-plastic families.

Glass was not the only reinforcing material discussed; attention was given to steel wires, beryllium, ceramic fibers, and other filaments.

• **Current program changes**—The most significant changeover now in the works for the glass-reinforced plastic case is the *Minuteman* three-stage vehicle. Wright Air Development Division has begun a program to demonstrate the suitability of the manufacturing methods, optimization of controls, equipment and processes, and other parameters enabling the switch to take place with complete confidence.

The structures for *Minuteman* must be completely designed from the winding patterns and materials aspects. The Air Force's Ballistic Systems Division is known to be somewhat dubious about the ability of glass-plastic motor cases to do the job, although it is reportedly quite hopeful. The program technical personnel at BSD feel that the third stage and first stage are different in more than just size.

A contract to come up with an acceptable first-stage *Minuteman* case has been let to Thiokol Chemical Corp. But the latter is believed to have teamed up with the B. F. Goodrich Co., since Thiokol hasn't sufficient in-house glass-plastic winding capability.

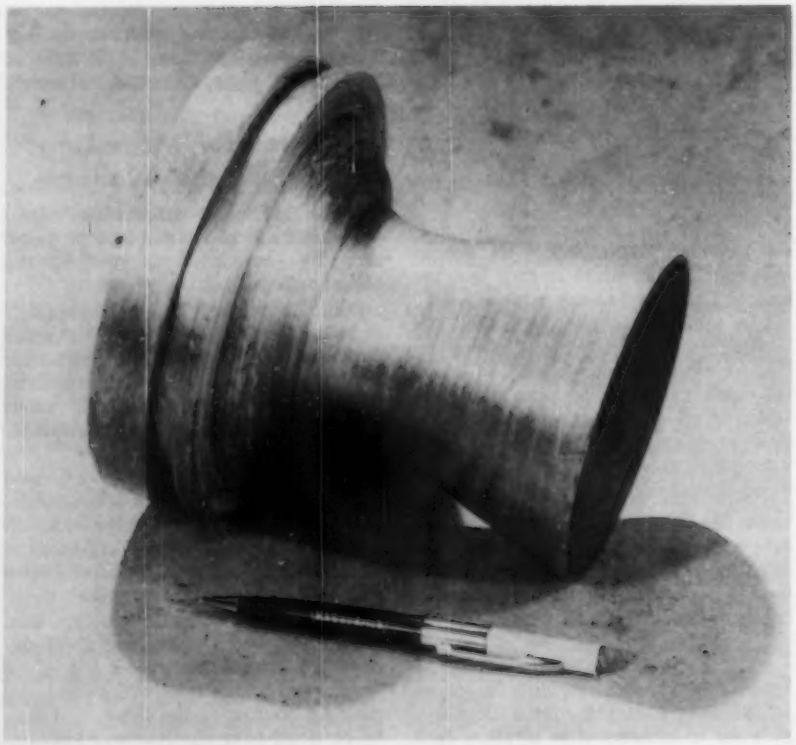
Use of glass on both stages of *Polaris A3* fleet ballistic missiles will significantly contribute to the goal of 2400 miles range. Currently being produced at Aerojet-General's Structural Materials Division in Azusa, Calif., the 13-ft.-long first stage case weighs only 800 lbs. without insulation, and is filament-wound with integral end closures.

The case has a stress level of 80,000 psi and a proof pressure level of 945 psi.

The second-stage motor case for the *A3* is only six feet long, weighs 200 lbs. without insulation, and is also filament-wound with integral end closures. Aerojet achieved its target weight figures on both cases.

Strength of the second-stage FBM motor is indicated by a stress level of 80,000 psi, and proof pressure level of 342 psi.

Nozzles for the *Polaris* are partly fabricated from cross-sectional segments



FILAMENT-WOUND rocket nozzle is one of the many avenues being explored by B. F. Goodrich Company in the field of reinforced plastics.

of fiberglass fabric with oriented fibers, compression-molded to size after being cut to shape and placed in a molding press. Refractory throat inserts are then assembled into the nozzle.

The Navy hopes to achieve mass stresses of over 200,000 psi within three years. Intensive research hinges on the fact that current fiberglass-reinforced plastics are using about half the available strength of the glass filaments. Since a glass case represents one-fifth the lead time and cost of a steel case, the Navy expects to push the glass-plastics.

Once missile rocket motors the size of *Minuteman* and *Polaris* are successful, little remains to prevent *Pershing* from traveling the same route. In the search for higher-strength cases for its "selective range" tactical missile, the Army has tried titanium cases which reached a yield level of 170,000 psi.

The difficulty with the B120VCA alloy was in the brittleness encountered at high strength levels. A similar problem had arisen in the *Minuteman* program, where a titanium alloy with 6% aluminum and 4% vanadium had reached strength levels of 138,000 psi, but only at the cost of brittleness.

As with the other programs now on the road to using composite cases, no timetable was revealed for the *Pershing* switch.

• **Glass-plastic submarines**—The possibility of a deep-diving submarine using a glass-plastic pressure hull was explored in a paper presented by J. E. Buhl, Jr., and J. G. Pulos of David Taylor Model Basin, and W. R. Graner, Bureau of Ships.

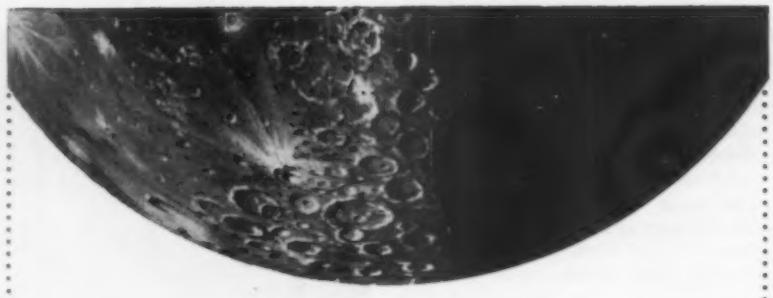
The authors reported on tests which had shown promise that composite glass-plastic materials might be successful. They expect development of materials superior to metals for the fabrication of submarine hulls.

In actual work conducted outside the Navy establishment, Aerojet-General is reported to have come up with a submersible hull shape using glass-reinforced plastics with a rubber-type sheath enveloping it. The hull is ring-stiffened.

The pressure hull, still in scale-model sizes, has withstood 10,000 psi external pressure, equivalent to a depth of 22,500 feet. Weight-to-buoyancy ratio is believed to be in the neighborhood of 0.5 for the material, indicating a positive buoyancy of the vessel, even when loaded with payload.

According to the paper presented to the symposium, the highest collapse pressure obtained was 7300 psi with a ring-stiffened hull. However, lack of specific details on the Aerojet hull prevent objective comparison of the results.

Extensive work for the Navy on the composite material hull was performed by Zenith Plastics Co. at its own expense. It was found that a higher glass



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content provided for greater resistance to collapse in the test shapes. Content of glass ranged from 69% to 84%, with the latter showing best strength.

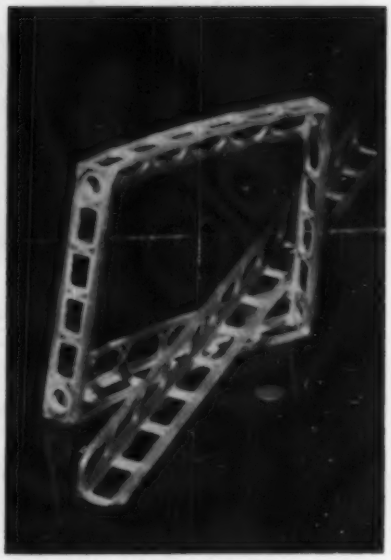
Both Navy and Aerojet researchers expressed concern over the effects of cycling on such a pressure hull. There is also some apprehension about long-term exposure to the deep submergence pressures. But work is under way to counteract both possible drawbacks.

A 50% reduction in strength was noted on test samples after 50,000 cycles, based on short-term compression strength. In long-term loading, unidirectionally wound glass-reinforced epoxy laminates, after immersion in water under flexural load equivalent to 56% of the short-time flexural strength, failed at 1000 hours.

• **State of the art**—George Peterson, Materials Central, Wright Air Development Division, said that most of the improvements in high strength-to-weight materials has been in component materials, rather than fabrication techniques.

Included in the component materials were vitreous fibers, silane coupling agents, and high-temperature, high-strength polyester, epoxy, phenolic and silicone laminating resins.

"AF considers that, even with the advances made to date and the continued effort in the area of new and improved component materials for filamentary structural composites, only isolated inroads have been made to obtain fundamental materials which can provide major advances in high strength-to-weight ratio composites."



STRUCTURAL MEMBERS being perfected by Goodrich include this "chain frame."

Peterson singled out for improvement reinforced materials, matrix materials, design of winding patterns and fiber orientation, and processing or fabrication techniques. He also called for a better understanding of the mechanisms of failure.

Ralph J. Brown, head of the preliminary design department of Aerojet's Structural Materials Division, cautioned that neither glass-reinforced plastics nor other composites are substitutes for metals.

"It's still necessary to design a structure around the benefits of these materials," he said, "and we still can't use composite filament-wound materials anywhere we like."

Brown pointed out that there is still no company in the business of making filament-winding machinery for missiles.

"And it's probably a good thing," he added, "because every time a company has to build its own, it uses what it learned from its predecessors, but improves on it. The result is an evolutionary improvement in fabrication machinery and techniques."

• **Prestressed pressure vessels**—A large step forward in increasing the strength of spherical pressure vessels was described by G. B. Wills and S. A. Dunn of Bjorksten Research Laboratories, and H. R. Worthington, Jr., of Scientific Engineering Institute. Their paper contends that the theoretical burst pressure of a thick-walled spherical pressure vessel can be greatly increased by pre-stressing the vessel.

Pre-stressing can be achieved, the authors said, but utilizing continuous filament-wound wall construction and controlling the tension with which the filament is applied. Through pre-stressing it is possible to obtain a uniform tangential stress throughout the vessel wall just prior to failure at burst pressure, rather than tangential stress varying as the inverse cube of the radius.

Effects of pre-stressing increase with wall thickness, and the paper points out that a pressure vessel made of material having an ultimate tensile strength of 100,000 psi, 9-in. thick wall, and 6-in. internal radius, will contain 530,000 psi in pre-stressed condition, but only 170,000 in un-pre-stressed condition.

• **Future for rocket cases**—Forecasting what is expectable from glass-reinforced plastic rocket motor cases in the near future, Elden Hawkinson of Rocketdyne described a solid-propellant motor case with the following properties:

—One nozzle port, probably with the nozzle wound in place.

—A length-to-diameter ratio between two and five.

—Case-wall operating stress level of 155,000 psi with a stress level at burst of 200,000 psi.

—Case modulus of 9 x 10^6 psi.

—Strength-to-density ratio of 2.5 million in. at burst.

—Except for possible metal skirt attachments, filament-wound in place, and a small polar boss at the forward end, no metal parts either in the case or in the nozzle reinforcement. ⌗

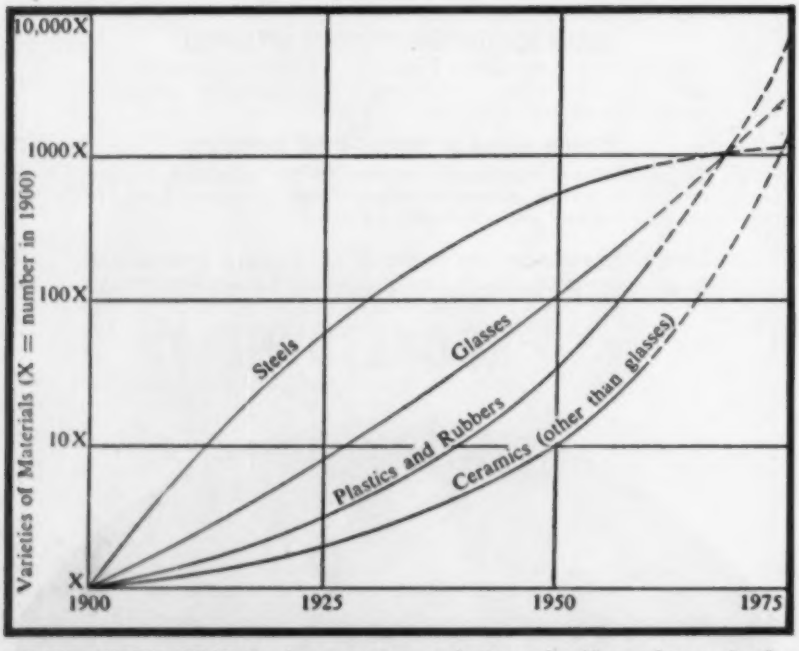


CHART SHOWS THAT development of new plastics and rubbers, glass, and other ceramics will exceed steel in a few years. (Chart courtesy University of Michigan)

LOFTI Data Changes Thoughts on VLF

THE NAVY is taking a new look at very-low-frequency radio propagation as a result of information gathered with the *LOFTI* satellite.

Preliminary data indicates that some of the generally accepted concepts of VLF and its relation to the ionosphere may be due for revision. Principally, the experiment showed that while the ionosphere does reflect a large portion of low-frequency radiation back to earth, a substantial amount goes through and into space.

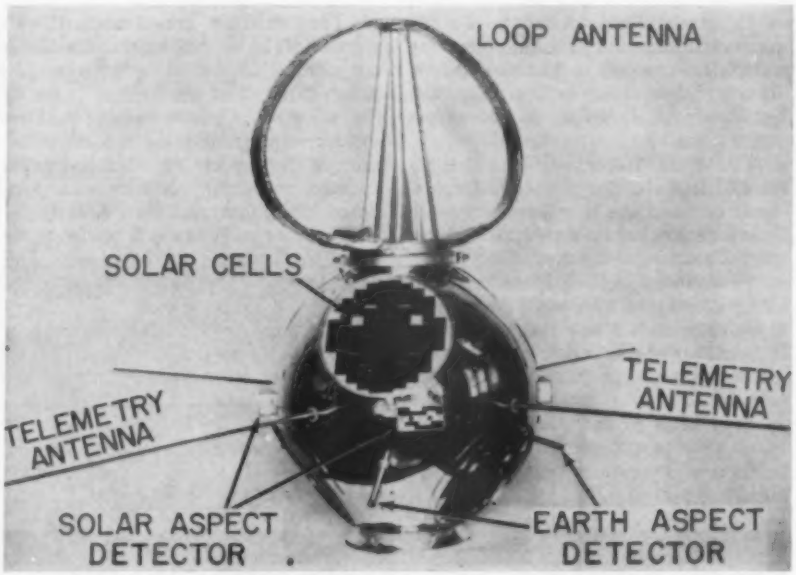
Considering this newly discovered phenomenon, Navy scientists foresee several important applications not previously considered. First, they say, it opens up the possibility of using VLF to transmit navigational data from earth stations to manned or unmanned space vehicles. Here, these frequencies have two important advantages:

—VLF is much less subject to interference by magnetic storms and other ionospheric disturbances.

—The longer receiving antenna and wider transmission beams of VLF require much less accuracy in aiming transmitting antennas to beam signals to spacecraft at long ranges.

The Navy says also that the experiment opens up the possibility of using satellites as a communication link with submerged submarines. Only the very-low frequencies penetrate the water's surface. Present high-powered VLF shore stations are vulnerable to attack and limited in range. Satellite stations would have considerable advantage in coverage and relative invulnerability.

There are no immediate programs to implement these new-found concepts into working space projects. The use of VLF poses some problems of its own which would have to be solved before practical systems could be developed. In the meantime, however, a whole new field of scientific investigation has opened up that could have a significant effect on advanced space communications systems. ⠿



Discoverer XXII Orbit Failure Studied

DISCOVERER XXIII, slated for launch in about two weeks, may be delayed until malfunction of *Discoverer XXII* can be determined.

The exact cause of *Discoverer XXII's* failure to achieve orbit had not been determined by presstime, but an Air Force spokesman indicated that the cause was suspected to be a "mechanical malfunction—possibly in stabilization" of the *Agena* vehicle.

Launch, staging and separation sequences were all determined as "nominal" by the Pacific Missile Range tracking site at Point Mugu, Calif., and the entire shot appeared normal as it went out of the tracking station's range. But the vehicle failed to re-appear in an orbital path.

The recent *Discoverer* shot marked a first for the series—it was the initial use of Bell Telephone Laboratories' guidance system for the *Titan I* in the *Discoverer* series. The BTL system was selected to replace the prior tape-fed autopilot control method because its greater accuracy permits more precise control of apogee and perigee points.

Orbital weight of *Discoverer XXII* was 2100 lbs. for the *Agena* and 300 lbs. for the re-entry capsule. This is close to weights for all the recent shots with exception of *Discoverer XXI*, which had an orbital weight of 2450 lbs.

It had been planned to allow *Discoverer XXII* to remain in orbit between one and four days, depending on how successful an orbital track was achieved and on weather conditions in the off-Hawaii recovery area.

The capsule's "clinical zoo" contained everything from emulsion blocks for the Geophysical Research Division of Air Research and Development Command to six different algae types gathered from springs and geyser runoff areas in Yellowstone National Park. In addition, it carried two different types of virus, including one first isolated in the 1930's and maintained under controlled laboratory conditions since that time. Neither it nor the other, an entero-type virus, are contagious to humans.

Certain types of living tissues and cells were carried by *Discoverer XXII* similar to those carried by *Discoverers XVII* and *XVIII*—cells from human bone joints, including cultures exposed previously to radiation in the two earlier *Discoverer* shots; spores; and living tissue from the brain of an embryo chicken.

One non-biological experiment contained in the capsule was a set of silicone samples similar to the materials used in solar cells. This was intended as a test for Space Technology Laboratory in its study of radiation effects on solar cells and solar cell materials. ⠿

Described to ARS . . .

Sapphire Whiskers for Safer Re-entry

PALM SPRINGS, CALIF. — Future spacecraft may use whisker-composite materials—expected to be three to four times stronger at white heat than any high-strength alloy on a pound-for-pound basis.

Dr. W. H. Sutton, of General Electric's Missile and Space Vehicle Department, outlined the development at the American Rocket Society's Lifting Re-entry Vehicle Conference.

Preliminary work is aimed at combining aluminum with whiskers of pure sapphire in such a way that one square inch of composite could withstand a tension of several hundred thousand pounds.

Sponsored by the Bureau of Naval Weapons, the program is designed to achieve a strength-to-weight ratio of 600,000 in. at 2000°F.

The whiskers are combined with aluminum as a bonding material. A completely successful composite will have nearly all of the stresses borne by the whiskers. Combination procedures include impregnating the molten aluminum with a pack of whiskers under vacuum or mixing whiskers with powdered aluminum and then heating.

A major difficulty is a tendency for pores to appear in the composite. This occurs when the bond between the constituents is incomplete.

The sapphire whiskers are grown by oxidizing aluminum in a hydrogen-water vapor atmosphere. The alumina is deposited as single-crystal growths.

One critical area is in the establishment and precise control of all the conditions present during the growth of the whiskers and the fabrication of the final composite material.

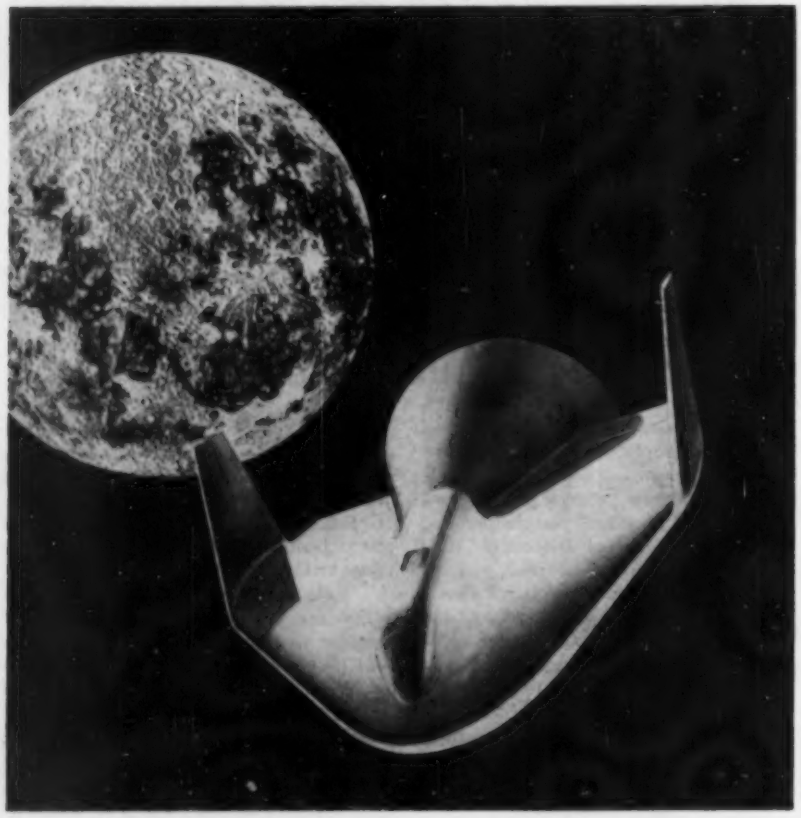
Plans are under way to develop composites using steel or other high-strength refractory metals.

• **Re-entry Techniques**—The destructive heat stress caused by re-entry conditions could be held within acceptable limits by integrating protective materials with the vehicle body structure.

This would eliminate the need for independently-mounted "shingles" despite the problems of vehicle buckling and distortion, said S. Levy, of G.E. General Engineering Laboratory.

The integrated approach accepts the stresses for the sake of light weight and good maneuverability. The shingle method protects against these stresses with free-mounted insulation material but accepts some sacrifice in weight and maneuverability.

Pyrolitic graphite applications were discussed by Dr. S. M. Scala, G.E., MSVD, in nose and leading edge areas. The material would offer heat protection under long-time flight conditions that produce gas temperatures of about 13,500°F and surface temperatures of about 4500° F. ⌗



A Cooler Approach to Re-entry

MANNED SPACECRAFT designed by Douglas Aircraft would cut down re-entry heat by "mushing" and rolling through the atmosphere, instead of depending upon heat-absorbing materials. Wind-tunnel model tests show that the design has a gliding ability comparable to that of a DC-8 jet transport.

Gilruth to Choose Date And Astronaut for MR-3

MERCURY DIRECTOR Robert R. Gilruth now has full authority to choose an astronaut and schedule the first manned ballistic flight when he decides the time is ripe.

NASA has approved Gilruth's checkoff list of remaining items. When he is satisfied, Gilruth will order the beginning of the 12-day countdown in preparation for *Mercury Redstone 3*.

Four major items remain on Gilruth's list—another *Little Joe* flight, centrifuge tests for the three finalist pilots, completion of landing bag drop tests and completion of the pilots' familiarization with system and capsule.

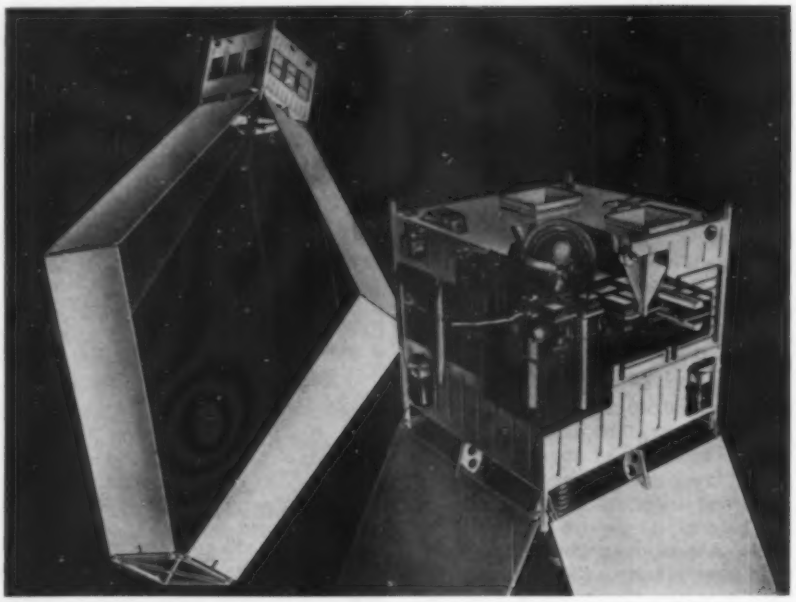
The *Little Joe* flight date has not been set, but it may take place the week of April 17.

The air drop tests already appear to have proved out a design change on the capsule landing bag—the addition of 24 cables of ¼ in. diameter to strengthen its connection with the capsule heat shield. However, more drops will be made to be certain.

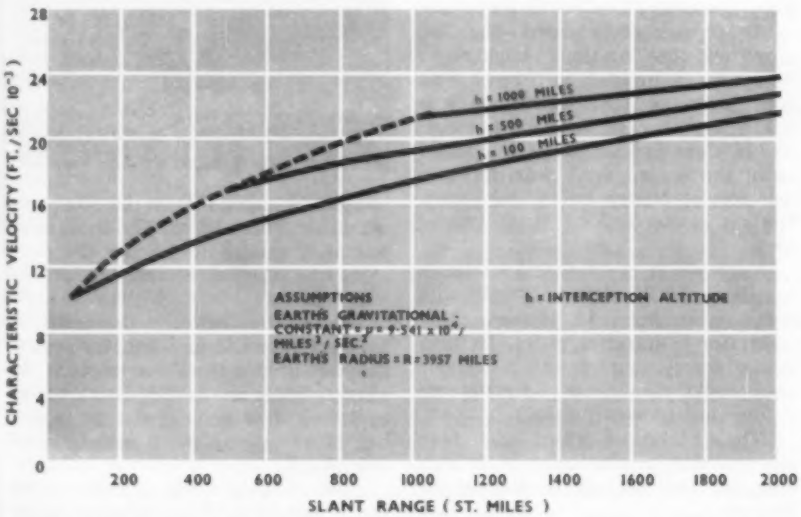
The astronauts themselves must certify their system familiarization. ⌗

Franco-British Report Sees Satellites Up by '64

by Bernard Poirier



COMMUNICATIONS SATELLITE design offered by Hawker Siddeley Group and SEREB in Western European industry's first aerospace study project.



VELOCITY REQUIREMENTS (5K ft/sec. loss) for nuclear interception of satellites.

ONE OF the most ambitious plans for joint space cooperation by Britain and France would take $800 million over the next four years.

Scientists of Hawker Siddeley and Société pour l'Etude et la Réalisation d'Engins Balistiques who collaborated in a recent report contend that, given a green light by July 1961, the combine could orbit satellites by December, 1964.

Assuming minimum blind avenues of implementation, they say only $300 million is needed for "research, equipment, data acquisition and handling."

Development of carrier vehicles (unspecified) is estimated at $300 million and specific space applications, $200 million.

The report states Compagnie de Télégraphie Sans Fils of France is presenting with SEREB a satellite navigation system based on the use of atomic clocks which could compete with Doppler systems. (CTSF has been credited recently in the development of a new Maser electronic screening system.)

• **Satellite details**—One Communications Satellite design would provide satisfactory operations in most orbits. The total weight of the satellite would be about 550 lbs. To be projected in one particular orbit would require a launch/payload ratio of about 350 assuming 250 lbs. specific impulse.

This stabilized satellite with high radio power could operate between 4000 and 10,000 miles. For a system serving mainly the Northern Hemisphere, a 63° inclined orbit has a distinct advantage.

The report says: "In particular, the apogee would remain at any particular latitude, thereby cutting down on the number of satellites necessary to provide a continuous (communications) service." Perturbation could rotate the system around the polar axis by about 15° per month. Assessment of this would determine the total satellites needed.

Their design requires stabilization of the satellite so it points earthwards and would use infrared radiation sensitive photo-cells to align with the horizon.

Initially the stabilization system would contend with residual angular velocities after separation and during the erection of the satellite from its horizontal position (see photo).

A known but varying angular velocity must be applied to maintain an earthward direction of the satellite as opposed to a tangential inclination, the report says. The torques required for correction would be beyond the stabilization characteristics of the earth's gravitational field.

Constant corrections particularly would be required to offset solar radiation and possible drag effects in the perigee region.

• **Temperature control**—The Europeans determined the correction device should rely on a propane fed reaction (jet) system. They dismissed consideration of a mixed reaction, jet/flywheel system which can be complicated by a high rate of leakage and extended thrust operations.

Satisfactory temperature control to protect internal electronic functions would be "accomplished by the use of specific surface finishes with absorptivity/emissivity ratios permitting regulated influx and efflux of heat."

The satellite would vary in distance from 12,500 miles to 300 miles, with a variable aerial beamwidth. The aerial's maximum gain would be 18 db and the minimum, 3 db. By establishing a mean value of 10 db at 4000 miles for consideration of one watt transmission under adverse fading conditions (of 10 db), the power received is established at about 4.5×10^{-14} watts.

Significantly, the reports says, "with a Maser type of receiver input the carrier to noise ratio for a 1 Mc/s bandwidth is about 16 db. This is a great improvement on a conventional valve and even on a parametric amplifier type.

Their final analysis suggests frequency modulation for which the maximum usable bandwidth corresponds to a carrier to noise ratio of 12 db and for the Maser type of receiver, about 2.6 Mc/s (French=2, 6 MHz).

The carrier frequencies, then, would be 6000 Mc/s for ground to satellite and 2000 Mc/s satellite to ground with four 2.6 Mc/s wide bands using a non-demodulating I. F. repeater suitable for FM. signals.

The radiated power from the satellite would be 4 watts total. There would be 100 two-way telephone channels S/N ratio 40 db and 32 two-way channels, 50 db.

The choice of propane for attitude control (controle d'assiette) was determined by its ready volatility and stability compared with H.T.P. Kept at a constant pressure (350 to 400 p.s.i.) by pressurized nitrogen and separated by a plastic diaphragm, the propane would be controlled by a displacement type injector.

The French and British technicians came up with vaporization of the propane by heat from four travelling wave tubes via lithium compound heat sinks. Heat output would be about 60 watts.

Another communication system also was proposed which offers several alternatives depending on payload and orbit as determined by the apogee. One omnidirectional 60 channel satellite would apogee at 6000 miles, the second with 120 channels and a 9300 mile apogee and the last, another 60 channel omnidirectional design but with a low 2500 mile apogee. ⌗

Australia's Malkara Death To Bunkers

by Alan S. Hulme
Australian Minister for Supply

(Dramatic evidence of the Malkara's adaptability to jungle warfare, as described in the following article written for M/R, is shown in the photos at right of the weapon blowing up a bunker. The Malkara is solid-fueled, is 6.5 ft. long, has a 2.5 ft. wingspan and weighs at launch 206 lbs. It has a range of 2 mi.—Ed.)

AUSTRALIA'S *Malkara* wire-guided missile was designed for several roles of which one was tank destruction and another the destruction of bunkers of the type frequently encountered during the last World War.

Bunker defenses, often interconnected in an elaborate manner, were used extensively in the Pacific Theatres. Heavy casualties were experienced against them and, in at least one case, casualties amounted to several thousand men.

A bunker is designed to be strong overhead and, to the maximum extent possible, to resist blasts alongside. One vulnerable feature of any bunker is the frontal firing slot used by the defenders.

Owing to ballistic trajectories, a gun was generally ineffective except at close range. A guided weapon, on the other hand, can achieve sufficient horizontal flight to enter.

The Australian Army and the Department of Supply have conducted many tests against bunkers typical of those encountered in South East Asia.

These were of two sorts—the "log earth" and the "log stone" bunkers. In these tests, a trench was covered with three layers of 10-in. hardwood logs spiked together. The first type was covered by three to four feet of compacted earth; the second type, with three to four feet of broken bricks and stones. The slit measured 5 x 1 ft. at ground level.

Sixty-pound experimental warheads containing 35 lbs. HE were used with instantaneous fuzes. (A *Malkara* easily penetrates ½-in. steel plates. Its high kinetic energy coupled with a delaying fuze would allow even deeper penetration and greater impact.)

Three rounds were fired from about one mile with perfect accuracy. In each case, one *Malkara* fully neutralized the bunker.

Blast recording instruments in the bunkers indicated that all the occupants would have been killed. The shots were purposely guided to hit the slit edge along the vertical center line of the bunkers.

These trials clearly demonstrated field accuracy and high lethality against defenses of this type. For instance, an enemy bridge could be destroyed by exploding a substantial charge against one of its supports from a distance of several miles.

The *Malkara* would have almost the same precision as a sabotage party placing the explosive. ⌗

C-V, L-T Merger Will Form a Giant

Wedding of two companies with wide-ranging capabilities is seen producing one of top ten DOD contractors; officers chosen

COMBINATION of Chance Vought Aircraft, Inc. and Ling-Temco Electronics will make the new company one of the top 10 military contractors, and Dallas a major missile/space center.

Stockholders of both companies will meet by early summer to approve the merger and choose a new name for the company. Chance Vought's stockholders meet May 28.

Although the courtship was one-sided, the union may prove a happy one. Combined sales for the two companies for 1960 were $362 million, with combined profits of almost $7 million. Combined backlog—mostly government orders—totals more than $300 million.

The merger will give the new company a potential systems capability in the class of the Lockheeds, Boeings and Martins, many observers say.

• **Potential**—Vought has aeronautics, astronautics, electronics, range systems and research divisions, and subsidiaries in data processing, underwater engineering, industrial automation and mobile homes. It recently was awarded subcontracts for work on the B-70, *Dyna-Soar*, a NASA contract for the first stage of *Saturn* and prime contract for the NASA *Scout*. The company is building a multimillion-dollar space simulator center in Dallas.

Ling-Temco—with the added missile capability of Temco Aircraft, which it absorbed last June—did almost 80% of its business last year in electronics, communications, missiles and aerospace systems. It built the *Polaris* radio station, increased its *Nike-Zeus* acquisition radar transmitter program, and built radar transmitters for BMEWS, Iconorama systems for BMEWS, SAC and NORAD. L-T's divisions worked in sonar, environmental testing sound systems for missiles, electromagnetic reconnaissance and electronic countermeasures. Ling also held contracts in systems development and production on the *Terrier, Polaris, Hawk, Sergeant, Davy Crockett* and *Minuteman* missiles.

The merger culminated a drive begun several months ago by Ling-Temco to buy up a controlling share of Chance Vought's stock. Despite vociferous resistance by former C-V president Frederick O. Detweiler—backed up by court suits citing the anti-trust laws—Ling interests managed to corner 38% of Vought's stock.

Detweiler, recently named to the post of chairman of the board of C-V, will move out entirely after merger negotiations are completed. Gifford K. Johnson, former executive vice president, is Chance Vought's new president and chief executive officer. He will be president of the new corporation.

Other officers in the new corporation will be: chairman and chief executive officer, Robert McCulloch, who presently holds that position at Ling-Temco. Chairman of the executive committee will be James J. Ling, president of Ling-Temco. Executive vice president will be Clyde Skeen, who holds the same position at Ling-Temco.

All lawsuits filed by both companies against each other will be dropped.

• **Stock exchange**—New stock probably will be issued, with the same value as Ling-Temco stock.

Chance Vought shareholders will receive a $43.50 debenture per share in the combined companies' debentures and warrants. This debenture will be worth 1¼ share in the new company (for the first five years). Each debenture bears a 5½% interest coupon, plus a five-year warrant to buy 1/5 share of new stock at $30 per share, and a five year warrant to purchase 1/5 share of new stock at $40 per share. This was done to compensate for the higher value of Chance Vought stock.

Although Ling-Temco will be the surviving corporation according to the Boards of Directors agreement, Chance Vought is the bigger company. Its 1960 income was $3.9 million on sales of $213.9 million—of which 65% was in defense contracts. The company's totals slipped from income of $4.9 million on sales of $254.7 million in 1959.

Ling-Temco's 1960 sales approximated last year's at $148.7 million. The company managed to make up for a $16-million loss in planned sales when the Navy cancelled part of the *Corvus* missile program. Earnings rose slightly to $3.051 million, from $3.029 million.

The two companies have a combined payroll of about 20,000, 15,000 of whom are employed at Dallas. #

expansions

THE MARTIN CO. has set up a department to integrate all its nuclear chemistry activities at Baltimore and Quehanna, Pa. Dr. Charles E. Crompton will head the group. The department will include a new automated laboratory at Baltimore for processing "man-made" chemical elements, and a series of heavily-shielded "hot cells' leased by the company at Quehanna for remote handling operations.

ELECTRONIC SPECIALTY CO. of Los Angeles has acquired D. S. Kennedy & Co., which has facilities in Massachusetts, Texas, Iowa and Alabama. Stock will be traded at four shares Electronic Specialty for five D. S. Kennedy shares.

financial

Avco Corporation—Sales and earnings alike exceeded 1959 totals. Net sales were $322.7 million, compared to $306 million. Earnings reached $10 million, surpassing $9.6 million in 1959.

Lockheed Aircraft Corp.—The company moved into the profit columns during the second half of 1960 with earnings of $12.5 million for six months, reducing its net loss to $42.9 million. Sales rose slightly to $1.33 billion for the year ended Dec. 5, compared with $1.30 billion for 1959. Backlog stood at $1.22 billion, compared with $1.16 billion a year earlier.

Aerojet General Corp.—Consolidated sales for the corporation for the three months ended February 28 were $108.97 million, compared with $93.99 million the same period a year ago. The sales figures were up 16%. Earnings rose 17% from $2.1 million to $2.5 million for first-quarter 1961.

General Dynamics Corp.—Net sales for 1960 were $1.99 billion, compared with $1.8 billion the previous year. Net loss for the year was $27.1 million, after $80.3 million writeoff on the 880/990 program. This compares to a 1959 profit of $31 million, during which year the company wrote off $25.8 million on its jet program.

Research
And
Engineering
For
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MISSILES AND ROCKETS
MAY 29, 1961
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Electronics
Space Medicine
Re-entry

Federal Property Rules Need Changing

by John D. Truesdale

Supervisor, Operations Engineering Control
Missiles and Space Division
Lockheed Aircraft Corp.

IT'S BECOMING increasingly difficult for missile/space manufacturers to live with the regulations controlling the handling of government property—mainly because most of them were set up for aircraft-production-type contracts.

In general, the regulations, given in the familiar Armed Services Procurement Regulations (ASPR), have not been updated for missile/space research-and-development-type contracts.

• **Problems of transition**—Under production conditions, all special tooling is ordered by manufacturing divisions for use in the shop and on assembly lines. Under missile/space R&D contracts, however, a major portion of special tooling is ordered by engineering divisions, whose officials usually are not familiar with the workings of Federal special tooling regulations. Consequently, special tooling accountability procedures are not implemented.

Many engineering departments have yet to learn the meaning of "special tooling": an item of special tooling, as opposed to capital equipment (either contractor- or government-owned), is one which is peculiar to the needs of the government—that is, the equipment item is not a standard catalog item being procured for general-purpose applications.

It is generally believed that the government's intent is as follows:

1) The contractor shall not buy fixed-asset type equipment under the guise of special tooling.

2) The contractor shall maintain accountability records for special tooling.

3) The contractor shall have freedom to rework, modify or alter this equipment as may be necessary to perform the applicable contract. Should the contractor change the configuration of special tooling equipment so that it takes on the characteristics of a general-use capital equipment, the special tool must be transferred, for accountability purposes only, to the contractors' plant account as a government-owned capital item.

Some companies are erroneously establishing specialized support-equipment (special tooling), acquired with R&D contract funds, as plant equipment for which official plant account records must be maintained. Immediately upon delivery of this equipment, modifications become necessary and are freely made in order to get the job done. Technically, this is a violation of the regulations; plant equipment should not be altered, and if it is altered contracting officer prior approval is required.

The new factor causing this problem is the multimillion-dollar cost-plus-fixed-fee R&D contract. Prior to the missile/space era, R&D activities were relatively confined; for example, an aircraft could be developed and tested at the production facility. Prototype tooling was relatively inexpensive and could be adapted into the production line when the airplane design became fixed. The goal was always the same: mass production. There was, and is, very little said in ASPR about prototype, or experimental tooling. ASPR regulations are fundamentally written for production-type operations.

There was one area, even under production contracts, where the contractors were constantly running into disallowance problems. Special electronic checkout equipment complexes were allowable contract cost items, as long as they were not of a general-purpose, capital nature. When a number of standard, capital-type electronics components were assembled into the complex, and the cost of the entire complex was charged to the contract as special tooling, a wide area of interpretation became apparent.

Disputes on these matters usually did not arise until the time of contract-termination audit. Under today's missile/space contracts, 40-60% of the costs may involve this same type of electronic checkout, test and support equipment.

The lack of clear regulations and uniform interpretations will lead the contractors and the government down the primrose path to property-accountability chaos; and the problem may not be recognized until it is too late to trace any audit trails.

Chief Problems with Government Property Regulations

1) Regulations are not compatible with the needs of missile/space R&D.

2) Contractors cannot comply with the regulations as they are being interpreted.

3) Government organizations responsible for negotiating and administering R&D contracts have unintentionally misguided contractors with respect to property procedures.

4) Contract administration offices of the contractors consider the regulations' problem too procedural to warrant intensive consideration.

5) Industrial engineers and procedures writers, unable to obtain informed guidance, have set out on their own to solve the regulations' problem; however, the constant internal reorganization characteristic of missile and space contractors has seldom allowed the job to be finished.

'Design-as-you-go' attitude . . .

Missile/space programs are based on R&D contracts necessarily involving generalized work statements. Attempts to make definitive support-hardware requirements have generally proven impractical. As soon as a list is negotiated, it is obsolete.

As a result, a philosophy of "define-as-you-go" prevails with respect to support equipment. The project engineering organizations normally establish the need for support equipment. Based upon a description of such items, an administrator must decide on several possibilities:

1) The item may be of a specialized nature, and therefore qualified as contract special tooling.

2) It may be expendable—that is, it may be destroyed during test operations, and therefore qualified as contract material.

3) It may be a deliverable end item defined in the R&D contract, or in a supplementary supply contract specifically negotiated for support-equipment hardware delivery.

4) It may be of a capital nature—for example, a standard computer to be used at a government test base or tracking station. We would have to assume that there was a facilities' contract covering the test base or tracking station. However, such an item may be charged to the R&D contract with special approval of the contracting officer.

5) If the item does not qualify under any of these categories, it must be assumed to be either a) fixed asset, b) facilities' contract item, c) item of expense (overhead), d) item to be furnished by the government under a bailment agreement, e) item of GFE (government-furnished equipment) handed to the contractor for incorporation into a deliverable end item, or finally, f) item of GFE to be handled by the contractor as an item of special tooling or expendable material.

One thing is clear: the project engineer must have an administrator who is well-informed in matters of property administration, if he is to get the job done and still comply with the contracts.

Normally, government contractors have separate procedures and forms for ordering and establishing accountability for 1) contract deliverable end-item material and test material, 2) special tooling, 3) fixed asset and facilities contract items, 4) expense (overhead) items, and 5) bailment items. If these procedures do not implement the applicable ASPR identification and accountability regulations, or the administrator guesses wrong at the proper classification of property, the contractor will most certainly be headed for trouble.

• **Special tooling consoles**—One major contractor revealed an agreement with the contracting officer whereby removable, standard, capital-type components of special tooling consoles would be procured as fixed assets. Over a period of time the company probably will have difficulty maintaining these fixed assets on the books. An engineer working to tight schedules is not apt to report necessary rework of modification.

Also, fixed assets normally require strict location control for financial reasons. These consoles and their fixed asset components will, of necessity, have to move freely between work areas. This is an unusual misinterpretation of ASPR, because it is to the contractor's disadvantage. Generally, it has been agreed that any component of an item of special tooling, whether the tool is a console of a shop fixture, should be charged to the contract as special tooling, and identified and accounted for as a component of the tool.

• **Tagging special components**—Some contracting officers are requiring contractors to place capital-type plant equipment tags on components of special tooling equipment that are removable and may be used separately as general-purpose, capital-type equipment—e.g., an oscilloscope. Such a possibility naturally concerns the contracting officer because a component of special tooling need be accounted for on the tool record only, and may lose its identity in the course of modification or alteration.

At the termination of a contract, remaining special tooling inventory is normally compared to the total expenditures for special tooling. When there is an unreasonable discrepancy, the contractor may be reprimanded. On the other hand, tagged plant property must be accounted for according to the same procedure governing capital-type facilities (plant equipment). How does this affect the contractor? Under such circumstances the contractor *cannot* follow the contracting officer's instructions, and still comply with ASPR.

The reason is this: components of special tooling, regardless of their nature, are necessarily subject to continuous modification, rework and damage. As a result, those special tooling items, for which accountability records are established in the plant account, lose their configuration identity, and the government may demand that the contractor return the items to their original configuration.

To accomplish the complex tests required under missile/space contract work statements, many standard off-the-shelf equipment items must be submitted or exposed to destruct, or near-destruct conditions. Contracting officers have required contractors to tag these items and establish plant account records for them. It is obvious that such equipment will seldom be maintained in a condition or configuration required by the accountability regulations governing government-owned plant equipment.

• **Ground support equipment**—Under R&D missile/space contracts, GSE normally is not designated as deliverable under the terms of the contract. Therefore, one would logically conclude that this GSE is special tooling. This may cause difficulty, because many GSE items are standard, capital-type equipment items. Most contracting officers have required tagging of this equipment as plant account property.

Since engineers at test bases and tracking stations must continuously modify GSE, it is difficult for the contractor to comply with the regulations governing equipment which is accountable as capital-type, plant-account property. It is almost certain that the engineers will not obtain contracting officer's approval prior to altering this equipment.

• **Shop accessory dilemma**—Contracting officers, under certain Navy contracts, have tried to implement "Shop Accessory" controls on specialized equipment acquired with R&D contract funds. "Shop Accessory" is the Navy term for special tooling. The regulations governing Shop Accessories (OSTD 100) were intended for production conditions. Application of these regulations to R&D contracts has proven impractical.

Here are the reasons: R&D work is unreasonably restricted by freezing the design of an item of special tooling equipment and implementing design drawing control; also, it is financially impractical to require that components of special tooling test equipment be permanently married to the parent equipment item. Without the freedom to interchange components between equipment items, the cost of specialized equipment under R&D contracts would reach fantastic proportions.

This nation's successes in the missile/space field can be attributed primarily to cooperation and mutual trust between the government and its contractors in private industry. Continuous bickering over problems involving government property regulations could have a deteriorating effect upon this relationship. There is an urgent need to completely re-evaluate government property regulations and their application to current conditions. ⌗

names in the news

RUFFNER

LEVITT

KONKOL

TEBO

LYONS

David Z. Robinson: Assistant director of research for Baird-Atomic, Inc., appointed technical assistant to **Dr. Jerome B. Wiesner,** President Kennedy's special assistant for science and technology.

Benjamin F. Ruffner: Former director of the product research office, promoted to chief of technical staff for Boeing Airplane Company's Aerospace Division, Seattle.

Dr. Sherrerd B. Welles: Appointed corporate director of engineering and research, Sanders Association, Inc., Nashua, N.H., Previously he was manager of the Missile Systems Laboratory and served as technical assistant to the vice president in charge of research and engineering for Sylvania Electronic Systems.

L. R. Barr: General manager of the Lear-Romec Division, elected vice president and general manager of Lear, Inc., Elyria, Ohio.

George G. Brown, Jr.: Named manager of Vehicle Systems Programing at North American Aviation's Space and Information Systems Division, Downey, Calif. Previously he was the division's representative to the AF Ballistic Missile Division.

Dr. I. M. Levitt: Internationally recognized space scientist, astronomer, director of Philadelphia's Fels Planetarium of the Franklin Institute and M/R contributor, appointed a member of the board of directors of Decker Corp., Bala-Cynwyd, Pa.

John R. Edmonds: Appointed director of production for Allied Chemical's General Chemical Division, N.Y. Edmonds has been with the division 21 years in various technical and supervisory positions.

Charles W. Henderson: Named assistant to the president of Ets-Hokin & Galvan, Inc., San Francisco. Henderson also will be in charge of the company's Washington Office.

Dr. R. D. O'Neal and **R. H. Isaacs:** Vice presidents in charge of engineering and government relations, respectively, of the Bendix Corp., Detroit, elected to the company's administration committee.

William E. Bradley: Appointed manager of the Aero-Space Computer Section of Philco, Willow Grove, Pa. **Howard W. Edminister** appointed to the semiconductor sales engineering staff of the Lansdale Division.

Arthur A. Katz: Veteran of over 10 years' experience in the electronic computer field, named to the newly-created position of manager, applied programing, RCA Electronic Data Processing Division, N.Y.

Ezra Kotcher: Former technical director, Directorate of Advanced Systems Technology at ARDC, Wright-Patterson AFB, Ohio, appointed to form and manage a San Francisco Bay area office of Aerospace Corporation.

Kenneth M. Tebo: Appointed director of management control and analysis for the Milwaukee plants of AC Spark Plug Division of General Motors. Tebo helped institute the PERT (Program Evaluation Review Technique) for the Navy on the *Polaris* program, and will set up a new activity of this type for AC-Milwaukee.

Raymond E. Stankard: Manager of tactical warfare systems sales, named administrator of contracts for the Aero-Science Sales group of Goodyear Aircraft Corp., Akron, Ohio. **William L. Leek,** manager of metal sales, given responsibility for rocket motor case and lighter-than-aircraft sales.

Dr. Richard E. Hillger: Appointed vice president for research of AirTechnology Corp., Cambridge, Mass. With ATC since 1952, he participated in the AEC nuclear tests at the Pacific Proving Grounds and the Nevada Test Site, and also supervised the optical and photogrammetric instrumentation used in rocket-sled tests of inertial guidance systems at Holloman AFB.

John D. Gum: Former assistant director of systems engineering at Consolidated Systems Corp., Monrovia, Calif., promoted to director of engineering.

Lambert F. Lyons: Elected vice president-director of engineering of American Avionics, Inc., Los Angeles. Previously he was chief of the missile guidance department at Bendix-Pacific.

J. Nelson Lord, Jr.: Joins Washington staff of General Dynamics/Electronics. Former assistant to the president of the Allen B. DuMont Laboratories.

George Konkol: Former general manufacturing manager of the Parts Division at Warren, Pa., appointed general manager of Microwave Device Operations, Sylvania Electric Products, Inc., Mountain View, Calif.

Mundy I. Peale: President of Republic Aviation Corp., Farmingdale, L.I., elected to the Board of Directors of Bausch & Lomb, Inc., Rochester, N.Y. **Harold Schroeder** appointed head of the newly-created Optical Coating Process Department.

Lester K. Suydam, Jr.: Appointed semiconductor sales engineer for Philco's Lansdale Division with offices in Syracuse, N.Y. **A. F. Parker** named manager of export sales for Philco's electronic data processing systems.

William C. Hennings: Former manager of the Receiver Development Branch, appointed manager of the Space Systems Branch of Melabs, Palo Alto, Calif. **Hugh L. Gottfried** named manager of the Reconnaissance Systems Branch. Prior to joining Melabs, Gottfried was with the USN Radiological Defense Laboratory and the Electronic Defense Laboratory.

James DeLuna: Named director of Central Region Marketing for Northrop Corporation's Nortronics Division with headquarters in Dayton, Ohio.

Thomas B. Mechling: Elected executive vice president of Aero Geo Astro Corp., Alexandria, Va.

J. M. Bridgman: Appointed vice president and general manager of Litton Systems (Canada) Ltd., Beverly Hills, Calif. **Victor V. R. Symonds** named contracts manager.

contracts

NASA

$195,000—Armament & Control Section of GE's Light Military Electronics Department, for gyroscope utilizing electrostatic rotor suspension techniques. Subcontract from **California Institute of Technology Jet Propulsion Laboratory.**

$119,613—General Electric Ordnance Department, for development of a cryogenic accelerometer.

$80,000—Tracerlab, Waltham, Mass., for R&D on detection of atomic gases in outer space.

$44,219—Electro-Optical Systems, Inc., Fluid Physics Division, Pasadena, Calif., for analysis of tests needed to evaluate performance of electrostatic propulsion systems in space; and **$74,941** for ionizer development and surface physics studies.

MISCELLANEOUS

$550,000—The Panellit Division of Information Systems, Inc., Los Angeles, to furnish instrumentation to the **General Electric Company** for use at the Hanford Atomic Products Operation, Richland, Wash.

$125,000—United Control Corp., Seattle, from **North American Aviation, Inc.,** for power distribution panels and environmental control systems.

$125,000—Summers Gyroscope Co., Santa Monica, Calif., from **The Martin Company's Orlando, Fla., Division,** for spring-wound gyros for use in trainer missiles.

NAVY

$1,211,000—Republic Aviation Corp. from **Grumman Aircraft Engineering Corp.,** Army & AF, for guidance systems for *Bullpup* missiles, advanced research in space electromagnetics and qualification tests for subminiature electronic modules and work in the field of surveillance drones.

$453,640—Lenkurt Electric Co., San Carlos, Calif., for communication carrier system service between Cape Canaveral and Patrick AFB.

$334,384—Tracerlab, Waltham, Mass., for 58 air particle monitors.

$282,151—Aircraft Armaments, Inc., Cockeysville, Md., for design, development, and fabrication of missile trainer, firing set assemblies.

$274,257—RCA Defense Electronics Products, Moorestown, N.J., for spare parts for AN/FPS-16 instrumentation radars.

$200,000—Perkin-Elmer Corp.'s Electro-Optical Division, Los Angeles, for development of a miniature infrared spectrometer for airborne use.

$110,000—The Martin Co., Baltimore, for study of the structural aspects of large hydrofoil ships.

$55,106—Meipar, Inc., Falls Church, Va., for investigation of the use of solion devices as a new approach to accelerometer applications in guidance systems.

Servonics, Inc., Alexandria, Va., for production of automatic tracking system for search radar. Amount not disclosed.

ARMY

$58,804,827—Raytheon Co., Waltham, Mass., for ground support, engineering services, radar sets, field service documentation and production of the *Hawk* missile system. (Five contracts.)

$19,185,449—Western Electric Co., North Carolina plants, for an improved capability item in connection with the *Nike-Hercules* missile system.

$9,549,082—Aerojet General Corp., Sacramento, Calif., for rocket motors for the *Hawk* missile.

$5,913,521—Convair Division of General Dynamics, Pomona, Calif., for continued development of the *Mauler* missile system.

$4,405,849—Sperry Rand Corp., Salt Lake City, for product and production engineering services on the *Sergeant* missile system.

$4,000,000—Electronic Defense Laboratories, Sylvania Electric Products, Inc., for a research and development project in the electronic warfare field.

$3,804,912—The Martin Co., Orlando, Fla., for engineering services on the *Lacrosse* missile system.

$3,000,000—The Martin Co., Orlando, for artillery training kits for ground support equipment for the *Pershing* missile system.

$2,458,071—Food Machinery Chemical Corp., San Jose, Calif., for loader transporters and ramps for the *Hawk* missile.

$2,304,991—Nortronics Division of Northrop Corp., Anaheim, Calif., for launchers for the *XM78-3* target missile.

$2,898,961—Radioplane Division of Northrop Corp., Van Nuys, Calif., for *RP-76-3* target missiles.

$1,977,527—Nortronics Division of Northrop Corp., Anaheim, Calif., for *Hawk* missile wing assemblies.

$1,075,913—The Freuhauf Trailer Co., Los Angeles, for production of basic enclosure and trailer frames for the *Sergeant* system.

$833,000—Sperry Utah Company, Salt Lake City, for production of warhead components, missile containers and shop maintenance sets for the *Sergeant* missile.

$134,743—Douglas Aircraft Co., Santa Monica, Calif., for *Nike* missile system repair parts.

$47,827—Gilfillan Bros., Inc., Los Angeles, for a prototype accessory set; **$46,484** for *Corporal* missile system spare parts; and **$27,171** for *Sergeant* missile telemetry equipment.

AIR FORCE

Minneapolis-Honeywell Regulator Co. from **Boeing Airplane Co.,** Seattle, multimillion-dollar research and development contract for work on the *Dyna-Soar* manned space glider program.

$1,500,000—Sylvania Electric Products, Inc., Mountain View, Calif., for engineering and production of ground countermeasures receiving equipment.

$1,448,292—Semiconductor Products Division of Motorola, Inc., from Autonetics Division of North American Aviation, Inc., for high-reliability transistors to be used in inertial guidance, flight control and ground checkout equipment being produced for *Minuteman*.

$981,952—Yardney Electric Corp., N.Y., for repair kits for *Bomarc* missiles.

$150,000—American Machine & Foundry Co., Greenwich, Conn., for components and related ground support equipment for *Titan* launchers.

$100,000—North American Aviation, Downey, Calif., for storage of *GAM-77* missiles.

$20,000—Tracerlab, Waltham, Mass., for development of instrumentation to detect toxic gases at exotic fuel fabrication sites.

Marquardt Corp., Van Nuys, Calif., from **North American Aviation, Inc., Space and Information Systems Division,** for continuing production of inlet control systems, components and spare parts for the *Hound Dog* missile. Amount not disclosed.

reviews

SPACE TRAJECTORIES, edited by the technical staff of Radiation Div., Radiation Inc., Academic Press, New York, 298 pp., $12.

If the reader can ignore the uneven treatment of the subject—a usual condition when symposium papers are merely scooped up and thrust into a book—he will surely find some helpful material in the present text.

For example, Rudolf Hermann, University of Minnesota, does a good job surveying re-entry trajectories and problems of hypersonic flow; G. B. Westrom, Aeronutronics, presents a cohesive picture of trajectory constants; and there are other articles worth reading. Unhappily, some of them are only distant relatives to the field of space trajectories, the subject of the book

The papers resulted from a two-day symposium sponsored by the American Astronautical Society, the Advanced Research Projects Agency, and Radiation Inc. on Dec. 14-15, 1959, intended to cover the space trajectory field.

ELEMENTS OF FLIGHT PROPULSION, Joseph V. Foa, John Wiley & Sons, Inc., New York, 445 pp., $12.50.

Here is an excellent book on propulsion which disbelieves in nagging a technical problem to death. Instead, it treats general propulsion engineering concepts with conventional analytical tools but wielded with some originality and conciseness.

The book is meant to be used for creative work in the propulsion field and for evaluating new ideas. Thus, specific devices are discussed only to illustrate concepts and not merely to lead to a compendium of propulsion formulas.

Written by a professor of aeronautical engineering at Rensselaer Polytechnic Institute, the book is also recommended because of its extended treatment of nonsteady as well as steady propulsion flows.

MODERN MATHEMATICS FOR THE ENGINEER, Second Series, edited by Edwin F. Beckenbach, McGraw-Hill Book Co., Inc., New York, 456 pp., $9.50.

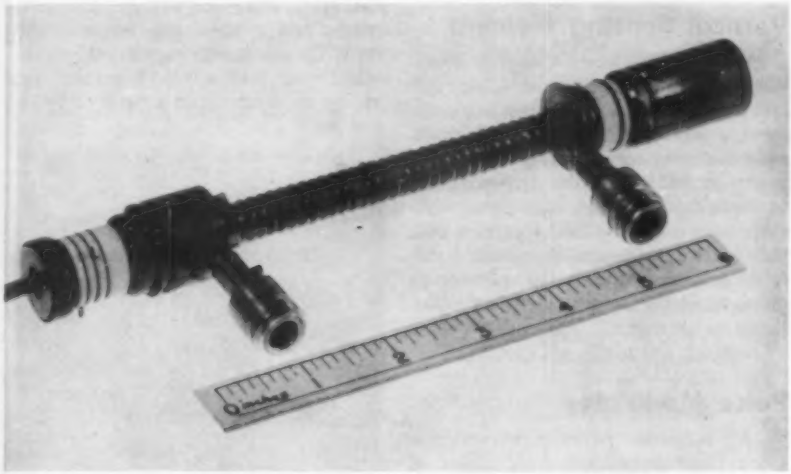
The material is divided into three parts: mathematical methods, statistical and scheduling studies, and physical phenomena. Each part includes contributions from some of this countrys' leading mathematicians.

Their intent was to give a broad survey of the applications of advanced mathematics to modern technology. Their papers are the result of a 1958-59 series of lectures conducted by the University of California, through University Extension.

In part 1, mathematical methods, involving operators in Hilbert space, distributions, transforms, semigroups, and asymptotic approximations, are put in perspective through applications to physical and engineering problems.

Part 2 is devoted to the modern probabilistic and statistical methods that are having such a strong impact on technology.

In part 3, the mathematical tools are applied through Monte Carlo methods matrix methods, and machine computations.



Miniature Amplifier

A miniature amplifier that will vastly increase the power output of future space satellite communication systems is available from the Sperry Gyroscope Co.

The amplifier—a traveling wave tube named the STX-182—is expected to produce up to 40 watts of power over an extremely broad frequency range in order to magnify simultaneously a great number of communications signals.

To generate the high output power, a unique electron beam focusing structure is employed to assure the exact aiming of highly concentrated electrical energy down the length of the tube. Tiny permanent magnets made of a special alloy are slipped over the tube, much like a row of precisely spaced finger rings, to form the focusing structure.

Circle No. 225 on Subscriber Service Card

Throttling Valve

An air-operated throttling valve with a Telfon diaphragm and a borosilicate glass body is available from Porter Engineering Co. The valve operates on standard 3-15 psig instrument air and can be used with either metal or glass pipe. It is fail-safe because air failure causes the valve to close completely. Both the setting of the diaphragm and flow through the valves are visible at all times.

The valve is recommended for handling all liquids except hydrofluoric acid and hot alkalies. It is effective from a vacuum of 10 mm. of mercury to 30 psig at an operating temperature of up to 400°F.

Circle No. 226 on Subscriber Service Card

Thermal Protection Evaluator

A standardized, calibrated, high-temperature materials-testing apparatus for operation in the 30-200 KW power range, producing 10,000-mph gas streams with stagnation pressures ranging from 1 to 20 atmospheres, is available from Thermal Dynamics Corp. With this tester, it is possible to measure heat conduction and resistance in thermal shock and ablation environments ranging from that seen by the leading edge of high-Mach-number planes like the B-70 to that encountered by a re-entering missile nose cone like the *Atlas*. Emphasis has been placed on design of equipment which will give consistent reproducible results. The apparatus is calibrated prior to shipment against established standards, and the accessories furnished permit recalibration by the operator during tests.

Circle No. 227 on Subscriber Service Card

Precision Regulator

Designed for operation with 6500 PSI systems, a lightweight pneumatic regulator operating at a constant outlet pressure is being marketed by Benbow Manufacturing Corp. Eleven outlet ranges are available from 0-60 psi 0-6500 psi.

Guages are furnished at both inlet and outlet, and regulator is manually adjustable by a Lo-Torque hand control. An automatic relief provides system protection and a special ball-bearing guide insures accurate sensing.

Construction is simplified for easy field service.

Circle No. 228 on Subscriber Service Card

Vibration Tables

Lightweight construction and low equipment cost are features of a series of vibration tables developed by the L. A. B. Corp. Developed specifically for reliability testing programs for electronic equipment, the vibration tables are available in two series—RH-5220 for horizontal vibration and RV-5340 for vertical vibration.

The machines produce simple harmonic table motion and employ the reaction principle of vibration, with the tables supported by spring and cable suspension systems. This feature isolates all vibrations from the floor and eliminates the necessity of concrete foundations to anchor the machine.

Circle No. 229 on Subscriber Service Card

Lightweight Mirrors

Optical mirrors for airborne systems five to 10 times lighter than conventional optical parts are available from Precision Lapping Co., Inc.

Owing to a process which utilizes a honey comb cross-section of the mirror,

there is no sacrifice of rigidity or precision of the reflecting surface.

Recommended for shock-resistant applications, mirrors can be furnished as flats, spheres or aspherics in diameters up to 48 inches. Made of glass or quartz, these units will withstand temperature variations of −80° to +165°F.

Due to the low coefficient of expansion of fused quartz, it is possible to attach supports directly to the honeycomb base of the lightweight mirror, a new and simple design approach for supporting structures having to overcome g loads, vibration and thermal shocks.

Circle No. 230 on Subscriber Service Card

Printed Board Connector

A device for connecting flat conductor cable to printed circuit boards or to flexible etched circuitry is available from The Thomas & Betts Co. Called POS-E-KON, the connector produces a direct conductor-to-conductor contact without solder. A continuous one-piece spring locks the cable into the connector. It provides a pressure point at each conductor contact.

In addition to its connector application, the device can be used to set up test points at any position on flat conductor cable. It can also be used to connect flat conductor cable to flat conductor cable without cutting conductors.

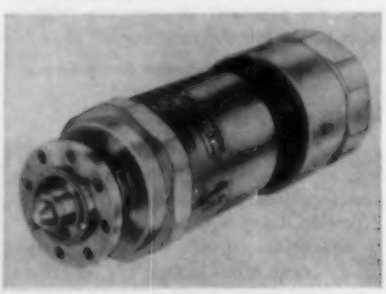
Circle No. 231 on Subscriber Service Card

Pressure Relief Valve

Pressure build-up and burning rate of solid propellants used in a stores ejector system are controlled by a valve, Model PRV-29M, available from Marotta Valve Corp.

Features achieved from inverted-type relief valves are: freedom from premature leakage, freedom from chatter and oscillation, excellent regulation characteristics and compensation for minor pressure surges without loss of gas.

Circle No. 232 on Subscriber Service Card



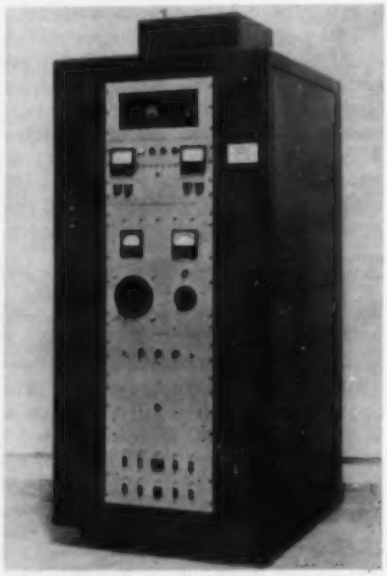
Vertical Sensing Element

Kearfott Division, General Precision, Inc. is marketing the C70 1806 002 electromagnetic vertical sensing element, a gravity-sensitive, liquid-damped, pendulous device which can be applied to any vertical sensing situation requiring an electrical output. A frictionless wire-suspended mass acts as the moving portion of two orthogonally mounted differential transformers to provide a phase-sensitive output signal proportional to tilt angle.

Circle No. 233 on Subscriber Service Card

Pulse Modulator

A versatile pulsed-power signal-source modulator with peak power of 1.2 megawatts has been introduced by Radiation Inc.



The self-contained Model 344M was specially designed for pulsing klystrons, traveling wave tubes, or magnetrons. The trigger generator, pulser, high-voltage power supply and filament supply for the tube under test are contained in a single seven-ft.-high cabinet. Meters are provided for power supply, voltage, power supply average and local currents, filament voltage and current for the tube under test. A high voltage pulse voltage divider monitor is included.

Circle No. 234 on Subscriber Service Card

Size 5 Servomotor

Helipot Division of Beckman Instruments, Inc. is commencing production of Size 5 servomotors.

The servomotor, designated Model 9005-1502-0, is only 0.865 in. long. Weight of this precision control component is 0.6 oz. Powered by 26-volt, 400-cycle reference voltage, the servomotor has a no-load-speed of 10,000 rpm. Torque-at-stall registers 0.1 oz. in., while rotor inertia is 0.18 gm.cm², providing an acceleration-at-stall of 39,000 rad/sec².

Circle No. 235 on Subscriber Service Card

Compact Telemetry Receiver

Vitro Electronics, a Division of Vitro Corp., is adding to its line of Nems-Clarke Telemetry Receivers a compact, lightweight precision receiver for FM, AM and CW signals in the 30 to 260 mc range.

This receiver features an AM Noise Limiter adjustable from the front panel, and a carrier operated relay to provide automatic carrier-on, carrier-off operation of auxiliary equipment through two contacts provided for that purpose. The action is indicated by a panel light.

Circle No. 236 on Subscriber Service Card

Smallest Hermetic Diodes

Two microminiature glass diodes are are available from Texas Instruments Inc.

These components, designated "MICRO/G(TR) diodes," have package diameter of 0.040 in., length of 0.060 in., and round leads providing a reduction in volume of 50:1 over conventional diodes with similar characteristics.

The two new devices being offered, the TI-2 and TI-6, are computer diodes which capitalize on diffused silicon mesa wafers whose surfaces have been oxide-passivated for optimum stability and reliability.

Circle No. 237 on Subscriber Service Card

Universal Bridge

Marconi Instruments has available a Universal Bridge Model 1313 which measures L to 110H, C to 110μF and R to 110MΩ, all with ¼% accuracy. Measurments may be made at 1 and 10Kc with an internal oscillator or throughout the audio range with external source and detector. Readout is

direct without use of multiplication factors. A unique feature is the main balance control, whose 140 discrete steps eliminate the conventional balance potentiometer. An interpolation control adjusts for final balance to ¼% accuracy.

Circle No. 238 on Subscriber Service Card

Sensitive Magnetometer

An extremely sensitive, lightweight, and compact magnetometer, capable of measuring the minute magnetic anomalies encountered in space, underwater and subterranean studies, has been developed by Arnoux Corp.

Suitable for detecting magnetic anomalies of 0.1 gamma or less, the magnetometer relays data in digital or analog form. The device can measure magnetic fields of the earth, planetary bodies, fields in the ionosphere and deep space, from solar and extrasystemic sources. The continuous signal has sufficient amplitude to feed data directly to telemetry systems or recorders. Featuring low power consumption of 0.8 watts at 200 ma from a 4 vdc source, the cylindrical unit is 7 in. long, 3 in. wide, but smaller models are available.

Circle No. 239 on Subscriber Service Card

Band Pass Filters

Miniature band pass filters designed specifically for use with telemetering systems and other transmission applications are available from Telonic Engineering Corp.

Filter characteristics such as center frequency, bandwidth and cutoff may be varied to meet individual requirements. Center frequencies are available covering the 200 to 2000 mc region with band pass widths of 2.5% to 20%.

Features of the TBP filters are small size and ruggedness. Their diameter is only slightly larger than the BNC connectors at each end. Other standard connectors are also available. Design is based on that of a lumped-constant filter with capacitance obtained by close-tolerance teflon and silver-plated brass sections. Coil forms and spacers are temperature-resistant, enabling operation at temperatures over 100°C.

Circle No. 240 on Subscriber Service Card

Helium Leak Detector

A high-sensitivity, dual-range helium detector that permits quick and precise location of helium leaks in tanks, piping and other fittings is available from Industrial Instruments, Inc. The two-range feature permits high sensitivity pickup of small leaks while minimizing overdrive of the meter on large leaks. The thermal conductivity sensitivity detector is powered with mercury cells, assuring long battery life. The unit includes a "transport position" on the range selector switch to short out the meter movement during transportation.

Circle No. 241 on Subscriber Service Card

Automatic Battery

A silver-zinc primary battery that will activate itself within a maximum of 15 seconds has been developed as

an electrical power source for missiles by the Missile Battery Division of The Electric Storage Battery Co.

Designed to provide ample power needed to transmit data from long distances, the 28-volt ESB Model 70 battery will discharge for 12 minutes with an electrical load of 5 amps. The voltage is regulated to limit fluctuation to ±5.4% of the 5-amp load.

Electrical capacity of the battery is one ampere-hour at the one-hour rate of discharge. It delivers 6.65 watt-hours per pound or 0.48 w/hr/in.^{3}

Circle No. 242 on Subscriber Service Card

Cathode Ray Tube Console

Automation Laboratories, Inc. has available a universal test console that can evaluate the performance of electrostatically and electromagnetically deflected direct-view storage and cathode ray tubes up to 30 in. long. The console design features include the capability of evaluating present and anticipated future storage tube characteristics.

The console, designated as Model 300B Universal Storage and Cathode Ray Tube Console, can test storage tubes having up to two writing guns and one flood gun. A central main control compartment allows an operator to readily control, record, and observe the characteristics of storage tubes.

Circle No. 243 on Subscriber Service Card

Digital Transducers

DeJur-Amsco Corp. has developed a complete line of digital transducers with true digital outputs. These devices reduce the overall size of instrumentation and control systems, increase their reliability and produce results which can be directly stored and used in digital computers.

Important features which characterize this digital transducer is its ability to sense different sources of energy in one miniature selfcontained package, and deliver a true digital signal output directly proportional to the amount of energy monitored. Also, its solid-state circuit configuration makes this transducer relatively impervious to ambient environmental variations.

Circle No. 244 on Subscriber Service Card

letters

Booster Initiative

To the Editor:

I wish to congratulate M/R for supplying such comprehensive coverage of this fascinating and rapidly developing sphere of endeavour.

Consideration of the present and proposed U.S. space plans leads me to put forward a few observations for readers' consideration.

In a recent issue of *The New Scientist* (5-1-61), Professor A. D. Baxter of de Havilland Engine Co. Ltd., England, in his article "Towards Giant Space Vehicles," produces a very interesting graph comparing the increase of payloads in orbit put up by U.S. and U.S.S.R., with time. This graph shows the Soviet curve to be consistently higher. The projected boosters *Saturn* and *Nova*, although lying on the U.S. curve, do *not* cause the U.S. curve to cross the extended Soviet curve.

Another point which is becoming obvious is that future orbital and planetary stations will need massive thrust boosters. These boosters seem to be missing from the U.S. programme. The U.S.S.R. has set 1967 (fiftieth anniversary of the 1917 revolution) to get a man on the moon. If they plan this, then boosters in the 5-10 million-lb.-thrust range must now be on the drawing board, if not already in development. Surely the proposal to develop such boosters as *Atlas G* and *Titan III* of 8-9,000,000 lbs. thrust (probably the same as present Soviet space boosters) is no way to take a lead in the "space race," especially as *Saturn* is almost ready for its first launch.

Through this apparent gloom I have detected one or two bright gleams of far-reaching thought. Firstly, in M/R, Oct. 31, 1960, p. 38, a suggestion is made that segmented solid boosters of up to 20 million lbs. thrust could be developed on present know-how. Secondly, a more detailed suggestion was made by Messrs. H. L. Thackwell and R. M. Pierce in M/R, Dec. 12, 1960, p. 35, in which they propose multistage solid boosters of from 7 to 21 million lbs. thrust for orbiting up to 130 tons. They also suggest that these boosters could be ready for use by 1964-66. Surely it is this type of thinking and planning that will give the U.S. the initiative. The advantages of this type of boosters are attractive:

a) Low cost per lb. of payload.
b) Flexibility in construction.
c) Can be ready soon.

Along with the development of these boosters, an equally intensive development programme should be conducted in the design and astromedicine of space vehicles and stations.

The success of *Polaris*, *Minuteman* and experimental segmented rockets should give the designers confidence.

If I may be permitted I would suggest the following points:

1) Acceleration of *Saturn* with the use of existing boosters as second stages for orbital flights with first-stage trials. This would put heavy earth satellites into orbit and regain lost prestige.

2) The immediate design and development of solid boosters of the range from 5-20 million, for orbital flights by 1964-66.

3) Concentration of *all* available resources on this project, and elimination of all duplication in work.

4) Parallel design and development in the fields of space vehicles, support equipment and space medicine.

If imaginative projects are initiated and pressed ahead, an American could be the first man on the moon, or even Mars.

Again, thanks for your excellent publication. I hope my observations will stimulate readers' thought.

C. P. Wilson
113 Sunderland Road, Forest Hill
London S.E. 23, England

Recalling Lenin

To the Editor:

I take the liberty of writing with respect to the very striking and timely advertisement published in M/R, Jan. 30, p. 53, sponsored by Microdot Inc. (quoting Lenin's "We have never rejected terror on principle . . .").

I would like to thank you for the courage shown by your publication in punching back the communists with their own nefarious words. As a chemist who reads extensively the technical literature, I was very pleasantly surprised to see such statements for the first time in a scientific periodical. I have shown the advertisement to several technical and nontechnical people and they all join me in thanking you for such an effective display of the truth and in asking at the same time that you print more such advertisements. Communist literature and pronouncements are full of statements as to the way our way of life is doomed and of how they plan to deal with us, hence there is no danger that your publication and advertisers will run out of ideas or quotations.

Senta S. Rogers
Washington, D.C.

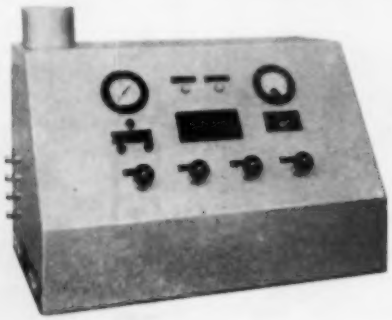
What the Jell

To the Editor:

You are careless. First you define and give the correct pronunciation of an Australian aboriginal name ("Boom Is on at Australia's Woomera Range," M/R, March 27, p. 43). Then (in the same article) you goof and locate the Goldstone transmitter in the "Mohave" Desert. Tsk, tsk.

Daniel K. Tillmanns
Corona, Calif.

A rather fine point. "Mojave" is the official name; "Mohave," which is also frequently used, is acceptable according to Webster's New Collegiate Dictionary—Ed.



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when and where

APRIL

Six Lectures on Synthesis of Intelligent Behavior, sponsored by Institute of Radio Engineers (IRE), and Society for Industrial and Applied Mathematics (SIAM), University of Pennsylvania, Philadelphia, meeting weekly April 10-May 15.

ASME Maintenance and Plant Engineering Conference, Bancroft Hotel, Worcester, Mass., April 10-11.

The Combustion Institute, Western States Section, Aeronutronic Division of Ford Motor Co., Newport Beach, Calif., April 10-11.

Cincinnati Sections of the Society for Applied Spectroscopy and Instrument Society of America Symposium, Cincinnati Gardens, Cincinnati, April 11-12.

Air Force Office of Scientific Research, Conference on Ultrapurification of Semiconductor Materials, New England Mutual Hall, Boston, April 11-13.

Symposium on Information and Decision Processes, Purdue University, Lafayette, Ind., April 12-13.

Cincinnati Section IRE, with Southern Ohio Section of American Rocket Society, 15th Annual Spring Technical Conference, Electronic Data Processing, Hotel Alms, Cincinnati, April 12-13.

Institute of the Aerospace Sciences, Army Aviation Meeting (classified), Washington, D.C., April 13-14.

Seventh Military Operations Research Symposium, ONR, Boeing Airplane Co., Seattle, April 17-19.

Seventh National Instrument Society of America, Symposium on Instrumental Methods of Analysis, Shamrock-Hilton Hotel, Houston, April 17-19.

Symposium on Chemical Reactions in the Lower and Upper Atmosphere, Stanford Research Institute, Mark Hopkins Hotel, San Francisco, April 18-20.

Bureau of Naval Weapons Missiles and Rockets Symposium, U.S. Naval Ammunition Depot, Concord, Calif., April 18-21.

American Geophysical Union, and American Meteorological Society, Annual Meetings, National Academy of Sciences, Washington, D.C., April 18-21.

13th Annual Southwestern Institute of Radio Engineers, Conference and Electronics Show (SWIRECO), Dallas Memorial Auditorium, April 19-21.

American Society of Mechanical Engineers, Metals Engineering Conference, sponsored with American Welding Society, Pennsylvania Sheraton Hotel, Pittsburgh, April 23-26.

Symposium on Structural Dynamics of High Speed Flight (confidential), Aerospace Industries Association and Office of Naval Research, AIA Auditorium, Los Angeles, April 24-26.

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- Corrosion-resistant
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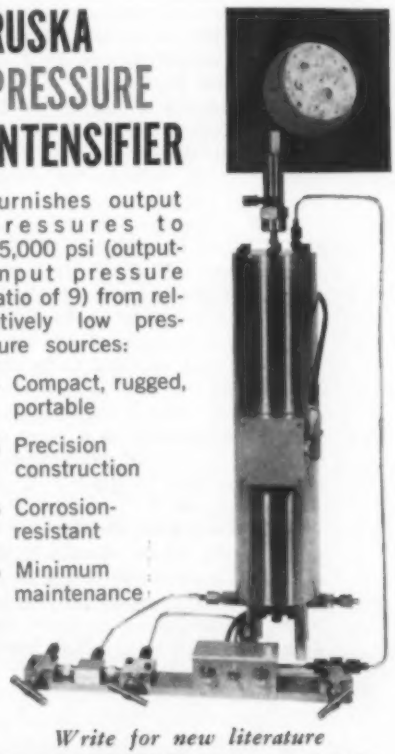

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editorial . . .

Basing Contract Awards on Merit

PRESIDENT KENNEDY'S proposal to step up *Minuteman* output by doubling production facilities in existing contractor plants is a welcome one.

There had been talk of going to second sources for the production increase. Although this would have had the advantage of spreading the honey around a bit, it would have been uneconomic.

For some of the *Minuteman* electronics, it may still be necessary to seek a second source. But, for the most part, even the existing facilities have not yet been pushed to capacity.

Beyond this, the most efficient way to step up production is to provide additional facilities at those plants where the program already is under way. There have been cases—a notable one recently—where second-sourcing was used as a means of cost reduction. But, in general, there is no cheaper way to expand output than to do it in the plant already geared up for it.

Experience is a mighty powerful money saver. Learning curves apply not only to production line workers but to management. One of the strongest points of U.S. industry has been its ability to decrease cost with an increase in unit output.

Cost factors on *Minuteman* already have gotten out of hand. Less than a year ago, top Air Force officers were talking of *Minuteman* as the "cheap" missile, estimating its cost in the hole ready to go as one million dollars per missile. They would be happier today if everyone would forget those estimates. Final cost may turn out to be closer to two million dollars each.

Air Force now is weighing the possibilities of the smaller *Midgetman* as a truly cheap missile. But, whatever the fate of *Midgetman*, anything done to hold down costs in the big *Minuteman* program is an important move.

For that reason, the decision to expand the program in the plants already holding contracts is a wise one. It obviously is not as politically attractive as a decision to go to second sources would have been. The temptation to throw some of the *Minuteman* business into so-called "depressed areas" must have been a strong one.

This question of using military contracts as a social tool to soften economic hardship in various parts of the country comes up periodically. It is a question to which there should be only one answer—"Never!"

Contract awards ideally should be based on technical quality of bids and past performance of the competing companies in meeting delivery dates and cost estimates. Anyone who thinks political pressure does not play a large role, however, is a starry-eyed idealist. It is imperative for every administration to resist this pressure to the greatest extent possible.

Unfortunately, this seems to have been forgotten in recent years. The unsightly scramble of major missile/space companies to prove that they are in a more depressed area than their competitors has been one result.

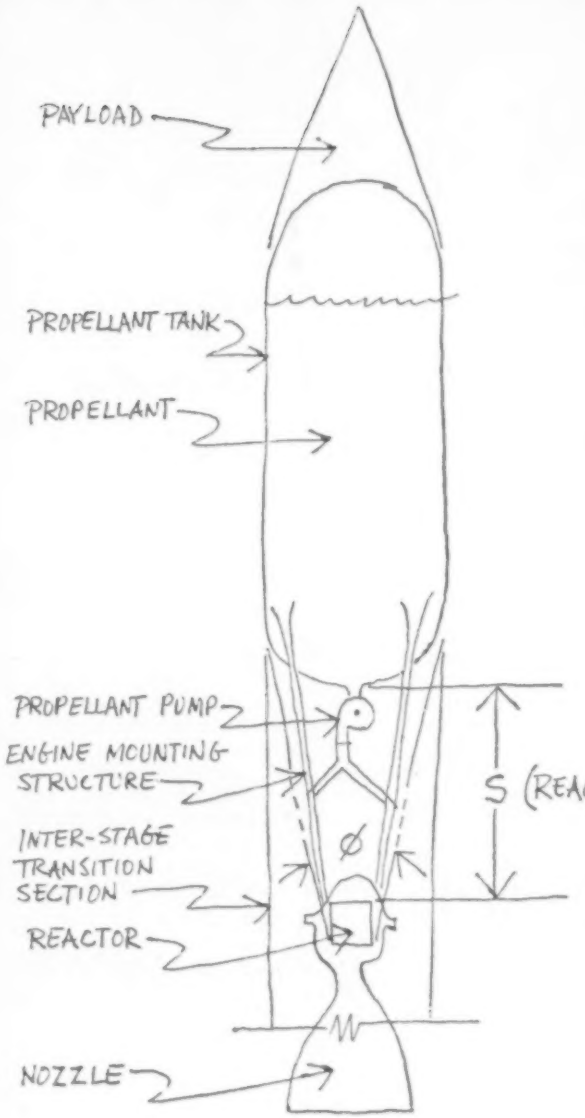
THERE ARE STRONG arguments against this depressed area philosophy. For one, any factor that operates against minimum costs in a military program puts us one down in the economic war with the Soviet Union. For another, any influence working against maximum technical quality within the minimum cost margins is wholly bad.

Too often it is forgotten that while the prime contractor may not be in a depressed area, subcontracts from that firm may be going to several depressed areas. The political scramble then can become fierce.

Recently, the manager of a medium-sized electronics firm was asked what his major problem is these days. His reply—"Outguessing the politicians." He went on to point out that far too many contract awards now depend on politics, rather than merit. Then he added—"I'm a Republican but I must admit it got a good deal worse under the last administration."

If the decision on the *Minuteman* program is an indication the present administration intends to reverse the trend, we are all for it. We hope Congress will take the same view.

William J. Coughlin



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- REACTOR DESIGN
- PROPULSION REACTOR START-UP
- NUCLEAR ROCKET SAFETY ANALYSIS
- RADIATION EFFECTS ON ROCKET SYSTEM
- FUEL ELEMENT DEVELOPMENT
- VEHICLE DESIGN
- CRYOGENICS

THE PROBLEM OF RADIATION HEATING IN NUCLEAR-POWERED ROCKETS

Martin liquid hydrogen test facility at Denver where heat transfer experiments are carried out.

The first flight of a U.S. nuclear rocket is targeted for the mid 1960's; but the achievement of this objective will depend upon the successful solution of many complex technical problems. At Martin, we are investigating all the areas listed above in a coordinated program designed to help solve these problems. An example of one approach to a problem area is illustrated. It concerns the propellant temperature elevation and excessive evaporation that might result from intense radiation created by the reactor.

Martin engineers at Baltimore and Denver are working on several approaches to the solution of this problem: 1) separation between the reactor and the propellant; 2) continuous cooling of certain components by the cryogenic propellant; and 3) shadow-shielding of propellant and components. Optimum solution appears to involve a combination of these alternatives, and can have a substantial influence on overall rocket system weight and performance.

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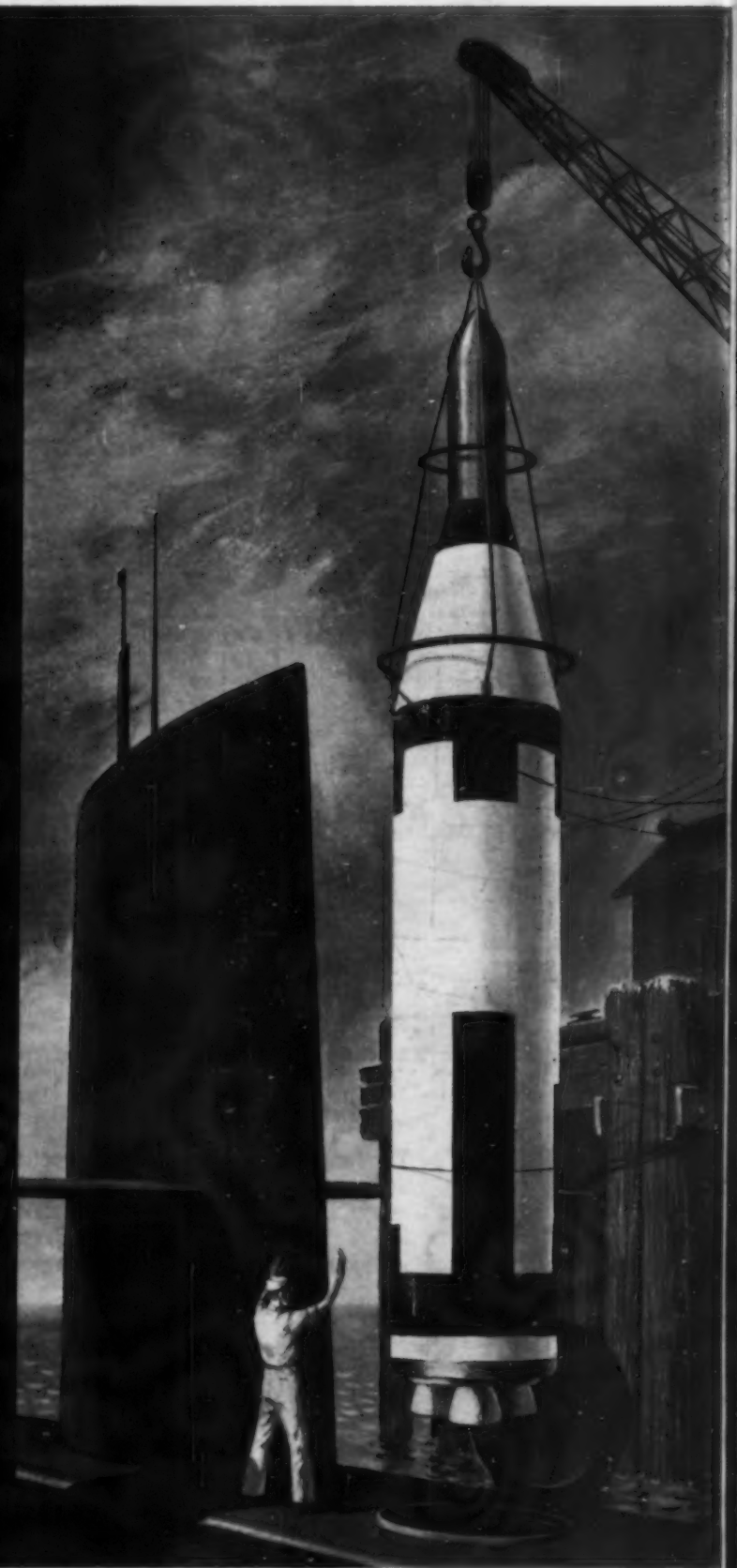

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